OVERSIGHT FOLLOWUP

EH2PUB/07-98/12SR

Followup Review of

Fissile Material Assurance

in the Department of Energy Complex

July 1998

Office of Environment, Safety and Health

TABLE OF CONTENTS

Abbreviations Used in This Report

D&D	**Decontamination and Decommissioning**
DOE	**U.S. Department of Energy**
DP	**DOE Headquarters Assistant Secretary for Defense Programs**
EM	**DOE Headquarters Assistant Secretary for Environmental Management**
ES&H	**Environment, Safety, and Health**
FM	**Associate Deputy Secretary for Field Management**
FMAWG	**Fissile Material Assurance Working Group**
IAEA	**International Atomic Energy Agency**
MAP	**Measurements Assessment Project**
MC&A	**Material Control and Accountability**
NDA	**Non-Destructive Assay**
NMMSS	**Nuclear Material Management and Safeguard System**
NN	**DOE Headquarters Office of Nonproliferation and National Security**
NRC	**U.S. Nuclear Regulatory Commission**
R&D	**Research and Development**
USEC	**United States Enrichment Corporation**

Executive Summary

The U.S. Department of Energy (DOE) is required to protect and account for its fissile nuclear materials—those of most concern are plutonium and enriched uranium. In 1995, the Office of Oversight issued a report that highlighted weaknesses in DOE's ability to accurately account for fissile materials and identified a number of potential enhancements. The 1995 Oversight report and a subsequent 1996 Inspector General report that reached similar conclusions were catalysts for a number of enhancements, including establishing a working group—the Fissile Material Assurance Working Group—to identify, communicate, and help resolve issues relating to the accountability and control of nuclear materials. The primary purposes of this followup report are to provide DOE and contractor managers with an independent oversight update on the status of fissile material assurance throughout the DOE complex, and to identify barriers to success and additional opportunities for improvement.

In the past three years, DOE sites, in conjunction with the Office of Nonproliferation and National Security, have made significant progress toward addressing some of the challenges associated with improving fissile material assurance. The most notable achievement is the completion of the measurement assessment project, which provided a comprehensive initial assessment of the adequacy of measurements for DOE fissile materials. This effort provides a good foundation for developing plans to ensure that DOE has defensible measurements and accounting records for all materials. Various DOE sites have also made progress in stabilizing and measuring certain materials. For example, the efforts to stabilize plutonium at Rocky Flats have been an important step in addressing the significant historical weaknesses in the nuclear material control and accountability (MC&A) program at that site. It is also notable that the Savannah River Site has completed measurements on most of its poorly measured materials, and the Y-12 Plant has developed a detailed plan to address large quantities of poorly measured materials, most of which were received from other sites. In addition, several sites have invested in additional measurement equipment totaling more than $20 million across DOE.

Despite the notable progress, many weaknesses in fissile material assurance remain, and DOE has not yet achieved an acceptable level of confidence in its nuclear material inventory. The data collected during the Office of Oversight's safeguards and security site profile effort—a detailed review performed in 1997 at the direction of the Secretary of Energy, encompassing DOE sites with significant quantities of nuclear materials—indicates that about half of the DOE sites have fissile material assurance weaknesses or important issues to resolve. The other sites exhibit weaknesses that required additional attention. The weaknesses evident today are similar to those identified in the 1995 Oversight report: materials that have not been adequately measured, inadequate records, deficient inventory practices, and poor accounting practices.

Because of the perception that physical security measures and material controls are generally adequate, DOE sites have not considered weaknesses in material accountability to be an immediate concern. However, weaknesses in fissile material assurance programs hinder DOE's ability to demonstrate that it can account for all nuclear materials, as is required by law and DOE policy. In addition, the weaknesses in fissile material assurance impact DOE's ability to meet various provisions of the DOE Strategic Plan, including provisions related to nonproliferation, D&D activities, external regulation, safety and health, international inspections, bilateral treaties, and efficient facility operations.

Resolving longstanding weaknesses in fissile material assurance is a challenging task. Even so, progress in addressing these weaknesses has been unnecessarily delayed by a number of factors. For example, the DOE processes for resolving issues and modifying

policy have not been effective, resulting in delays in revising DOE orders and guidance, including those related to fissile material assurance. In the absence of revised policy, various operations offices and sites are interpreting policy and implementing approaches in ways that are not consistent with the intent of DOE orders.

In addition, management at some sites has relied too heavily on security measures and not provided the support necessary to ensure that material is properly accounted for, as demonstrated by several recent instances where required physical inventories were not performed because operations were shut down to address safety concerns. In one instance, a site developed procedures to safely perform part of a required inventory only because site management determined that they could not afford to fail to meet a provision of an International Atomic Energy Agency (IAEA) agreement. Failure to perform physical inventories was also noted as a deficiency in the 1996 Inspector General report.

Thus, while some progress has been made, this followup review concluded that some DOE sites are not yet achieving the objectives of an effective fissile material assurance program, such as ensuring that all materials are accurately accounted for. In addition, there are indications that efforts to improve are losing momentum. Increased management attention at Headquarters and the field is needed to address site-specific issues and to ensure that DOE can adequately account for fissile nuclear materials, reasonably meet the commitments for offering materials to IAEA inspections, and effectively prepare fissile materials for safe and secure long-term storage.

OPPORTUNITIES FOR IMPROVEMENT

Site-specific Issues: Sites and organizations that are most directly affected and that need to take timely action are identified in parentheses following each issue.

1. **Resolve issues that have led to failures to conduct required physical inventories of nuclear materials at several DOE sites. (Hanford Site, Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and the Y-12 Plant)**

2. **Ensure that holdup is identified, measured, and properly reflected in inventory records, and that inventory records are updated as appropriate. (Rocky Flats Environmental Technology Site, Portsmouth Gaseous Diffusion Plant, Savannah River Site, and Y-12 Plant)**

3. **Ensure that Defense Programs approves an effective plan for measuring fissile materials at the Y-12 Plant in a timely manner. (Y-12 Plant, Oak Ridge Operations Office, and Defense Programs)**

4. **Accelerate efforts to develop and implement effective and realistic site-specific plans for addressing fissile material assurance weaknesses, including an assessment of impacts on DOE's ability to meet provisions of the DOE Strategic Plan. (All sites should examine their ability to meet the DOE Strategic Plan provisions. Particular attention to measurement plans is needed at Rocky Flats Environmental Technology Site, Los Alamos National Laboratory, Lawrence Livermore National Laboratory, Hanford Site, and Argonne National Laboratory-West)**

DOE-wide Issues: The following issues need attention at DOE Headquarters to achieve sustained improvement in fissile material assurance programs.

5. **Enhance management support for fissile material assurance by ensuring that program offices, operations offices, and contractors are held accountable for progress.**

6. **Enhance fissile material assurance program direction by strengthening and expanding the role of the Fissile Material Assurance Working Group and increasing coordination with the DOE Security Management Council.**

7. **Resolve issues that have delayed the review and reissue of the revised DOE order governing MC&A.**

8. **Perform a baseline reassessment of policy and guidance.**

1.0 Introduction

Ever since the earliest days of the U.S. nuclear program, the U.S. Department of Energy (DOE) and its predecessor agencies have been required by law—the Atomic Energy Act of 1946 (as amended in 1954)—to ensure that fissile materials, such as plutonium and enriched uranium, are properly protected and accounted for. Accurately accounting for fissile materials—referred to as fissile material assurance—can be technically challenging and has not always been effectively accomplished.

Waste material containing fissile material residues in a form that is difficult to measure

The Office of Oversight performed a followup review of its 1995 report on fissile material assurance.

Recognizing the difficult issues being faced by DOE sites, the DOE Office of Oversight performed a special study, *Increasing Fissile Inventory Assurance Within the U.S. Department of Energy*, which was published in January 1995. The 1995 Oversight study provided an in-depth discussion of fissile materials issues and measurement methods, and highlighted problems that required increased attention. It also provided a number of short-term and long-term opportunities for improvement that were intended to help address fissile material assurance issues. Because it was clear that it would take years to fully address the longstanding and diverse problems, one of the suggested enhancements was the formation of a steering group to ensure that fissile material assurance issues were communicated to senior management, that program offices and operations offices as well as contractors were appropriately involved in the decision process, and that a DOE-wide approach could be developed to address problems that affected multiple sites.

The DOE Office of the Inspector General reviewed internal controls over fissile materials at seven sites and found accounting problems at three of those sites. The problems involved failure to perform required physical inventories and weaknesses in measurement programs—similar to the problems noted by the Office of Oversight in its 1995 report and other inspection reports. The Inspector General report, published in April 1996, concluded that DOE should accelerate efforts to implement the improvements outlined in the 1995 Oversight report.

Since then, DOE has taken a number of actions to enhance fissile material assurance. As a DOE-wide enhancement, DOE established the Fissile Material Assurance Working Group (FMAWG), which includes representatives from DOE Headquarters, operations offices, and contractors, to serve as a forum for discussing issues and recommending solutions. In addition, a DOE-wide effort—the measurement assessment project (MAP)—was performed to assess the adequacy of measurements for all DOE

fissile materials and to establish plans for improving DOE's fissile material measurements.

In the three years since Oversight issued its special study, the factors that affect fissile material assurance have continued to evolve. For example, DOE has made decisions to accelerate the decontamination and decommissioning (D&D) and cleanup efforts at some facilities and has moved from a "planning and characterization stage" to one where many active D&D and environmental restoration programs are ongoing. The increased D&D efforts involves moving fissile materials from some facilities and consolidating those materials at other locations. In addition, DOE has offered a total of more than 12 metric tons of fissile materials up for inspection by the International Atomic Energy Agency (IAEA) and plans to offer additional fissile materials to IAEA inspections in the next few years (e.g., more than 20 metric tons of highly enriched uranium by 1999, according to the DOE Strategic Plan).

The followup review was performed because of indications that enhancements to fissile material assurance were not progressing as fast as expected.

A number of events that occurred in 1997—including internal DOE reports that raised security issues, questions about the effectiveness of security programs from current and former DOE contractor employees, critical articles in various local and national media, and Congressional attention—placed safeguards and security in the spotlight and served to heighten DOE management awareness of safeguards and security issues. Correspondingly, the Secretary of Energy directed several reviews of the effectiveness of safeguards and security programs, including a review of selected sites by the Office of Nonproliferation and National Security (NN) and a comprehensive review of all major DOE sites by the Office of Oversight. Both reviews concluded that there were no immediate risks to the protection of fissile materials but that prompt attention was needed to correct weaknesses at several DOE sites. The Office of Oversight's review of all major safeguards and security programs—also referred to as the safeguards and security site profile effort—was the most comprehensive review of DOE safeguards and security ever undertaken. As such, it provided a good snapshot of the status of safeguards and security across the complex. These site profiles, combined with other ongoing Oversight efforts, indicated that progress toward enhancing fissile material assurance was not as fast as expected.

The purpose of the followup review is to identify obstacles to timely enhancement of fissile material assurance.

Because of the relatively slow progress and issues identified at some sites, the Office of Oversight determined that it was prudent to perform a followup review of fissile material assurance. The primary purpose of this followup review is to identify obstacles to timely enhancement of fissile material assurance and determine what additional enhancements are needed to adequately account for fissile materials and meet related DOE strategic goals, such as those related to nonproliferation and IAEA inspections. This followup report focuses on DOE's progress toward addressing issues identified in the 1995 Oversight report and on issues identified during the site profile effort.

The main body of this Oversight report is intended to provide Headquarters, operations office, and contractor managers with an overview of the status of fissile material assurance across the complex and the actions that need to be taken to improve. Detailed discussions of selected issues are included in appendices, which are intended for managers with direct responsibility for fissile material assurance programs and other managers who are interested in particular subjects.

Like many technical disciplines, fissile material assurance and nuclear materials accounting use specialized technical terms that may be confusing to the non-specialist. For example, the subtle differences between similar terms, such as "inventory" (the listing of all materials at the facility and the amounts in each item on the listing), "inventory value" (the recorded amount of fissile

materials in a specific item), and "physical inventory" (the process of periodically determining how much material is present and its location) would not be readily apparent to a non-specialist. Therefore, to the extent practical, Oversight has attempted to minimize the use of such jargon and ensure that the issues are clear to DOE and contractor managers. To assist the non-specialist, the inside of the back cover of this report provides non-technical definitions of some frequently used terms.

2.0 Background

The problems associated with the adequacy of fissile material assurance often involve complex issues spanning a variety of subjects, such as nuclear physics, chemistry, statistics, nuclear radiation measurements, and accounting. Fissile material assurance problems have been encountered since the 1940s as is evidenced by the material balance information contained in the DOE report, *Plutonium: The First 50 Years*. These problems present themselves especially in the information associated with inventory differences, normal operating losses, and waste inventories. Various documents, including the 1995 Oversight report and the plutonium report, provide more detail on the history of the DOE nuclear program and issues related to fissile material assurance. The intent here is not to duplicate the information in those documents. Rather, this section provides a very brief overview of some of the more important background information needed to understand the problems and issues associated with fissile material assurance.

Scope and Purpose of Fissile Material Assurance

Fissile material assurance refers to accurately accounting for the fissile materials, primarily plutonium and enriched uranium, in DOE's possession. Fissile material assurance encompasses: measurement programs, accounting systems and records, physical inventories, inventory reconciliation and evaluation, and periodic reporting of the amounts of fissile materials on hand to sitewide and national data bases (see the inside of the back cover).

Fissile material assurance is legally mandated and needed for a variety of purposes.

In addition to the Atomic Energy Act, the U.S. has obligations pursuant to the Nuclear Nonproliferation Treaty and the U.S.A. Safeguards Agreement (MFCIRC/288) that require the U.S. to properly account for fissile materials. As well as meeting these legal mandates to properly account for fissile materials, effective fissile material assurance:

- Enables DOE to know how much material it has and where it is; such information is important to providing the proper level of physical protection and to site personnel involved with operations; criticality safety; environment, safety, and health (ES&H); and D&D
- Enables DOE sites to conduct and reconcile emergency inventories if security systems are compromised (e.g., a building evacuation after a fire alarm could result in a need to verify that materials were not removed during the confusion) or if an adversary claims to have stolen material from a DOE facility
- Provides the only definitive confirmation that protection measures have been effective (periodically verifying that materials are still present adds to the confidence that the protective measures have not been defeated)
- Provides a means of detecting theft or diversion of fissile materials
- Provides timely data so that process losses or holdup can be localized and analyzed and materials can be recovered or appropriately identified before significant quantities are allowed to accumulate and remain unaccounted for
- Is a prerequisite to offering fissile materials up for inspection by the IAEA.

Historical Perspectives on DOE's Difficulties in Maintaining Adequate Fissile Material Assurance

Providing an acceptable degree of fissile material assurance has always been a challenging problem for a variety of technical and operational reasons. For example, production processes, such as solvent extraction (transforming liquid nitrate to oxide), presented challenging measurement problems (e.g., sampling and measuring product streams in complicated series of pipes containing continuously flowing materials). Further, in most processes, some fissile materials inevitably end up as by-products (scrap); for example, material must be trimmed from a cast metal part. Scrap is often irregularly shaped and mixed with other materials so that the amount of fissile materials is difficult to measure. Fissile materials, like other process materials, also inevitably accumulate in process equipment and piping (holdup), or end up in forms that have low concentrations of fissile materials that cannot be economically recovered (waste).

Some forms of fissile materials could not be measured when they were produced.

For much of the DOE's history, the technology did not exist to measure the various chemical and physical forms of materials produced as part of the strategic defense buildup and related DOE efforts. Measurement techniques available in the early days of the weapons program (e.g., scales for weighing materials, chemical analysis, and mass spectrometry for element and isotopic measurements) were adequate for measuring pure materials, most solutions, and some waste. However, the remaining scrap, waste, and holdup materials could not be measured using available measurement techniques without further processing. Nondestructive assay measurement techniques for these materials were not available until the early 1970s.

In some cases, the inability to measure items was not a detriment to fissile material assurance. For example, weapons components, often amalgams of fissile materials and other metals, were difficult to measure without destroying the component. However, they were manufactured under stringent quality control and security conditions, so DOE could be confident that they contained the expected amount of fissile materials.

While DOE was processing fissile materials in support of the defense buildup, some of the errors inherent in estimating the quantities of fissile material contained in scrap and waste could be tolerated because the inventory was corrected when materials were recovered. For example, scrap materials were reprocessed and the material converted to a form that could be accurately measured. Also, equipment was periodically cleaned so that the holdup could be recovered and measured. In addition, waste products were packaged and held for incineration to ash, which could then be measured with some degree of accuracy.

Performing measurements of fissile materials in a shutdown process line

Additional problems with measuring materials were encountered during the late 1980s through the 1990s. The end of the Cold War resulted in a significant (around 30 percent) increase in the DOE's fissile material inventory as weapons were returned from stockpile and DOE accepted fissile materials from other countries. The changing needs resulted in production stand-downs and large quantities of fissile materials were left in forms that could not be readily measured. During this same period of time, nuclear operations at some facilities, such as the Rocky Flats Plant, were shut down for safety reasons, leaving materials in processes and temporary storage for what was expected to be a short period of time but ended up being for years. In these cases, DOE did not take

effective action to stabilize materials, clean out process equipment, or measure materials. Further, some processes, such as waste incineration, were shutdown permanently because of environmental concerns, and unmeasured waste inventories grew rapidly.

The inability to measure scrap, waste, and holdup hindered effective fissile material assurance.

Nevertheless, the inability to measure scrap, holdup, and waste materials significantly hindered DOE's ability to accurately account for nuclear materials. Sites often had to make estimates based on historical experience or observation; the accuracy of such estimates varied from reasonably good to poor. Over time, various materials were not processed or measured for one reason or another. Such material accumulated to the point where a significant amount of scrap and other unneeded fissile materials in various forms were placed in storage, with no near-term plan to process it to a measurable form.

Management attention to fissile material assurance programs has varied over the years.

In addition to the technological challenges, the attention devoted to properly accounting for fissile materials has varied over the 50-year history of its production and processing. In the early years of the defense buildup, all available fissile materials were needed to meet defense production goals. Further, because producing plutonium and highly enriched uranium was very expensive, there were strong financial incentives to recover as much fissile material as possible. Also, when DOE production facilities were operating, many of the processes (such as blending) depended on information provided by fissile material assurance programs, and the fissile material assurance personnel worked closely with operations and production personnel. These factors provided incentives to keep DOE's inventory of fissile materials up-to-date.

Now, as the nation's defense needs have changed, DOE's fissile materials are no longer recovered to meet weapons production goals—in fact, the U.S. now has more plutonium and highly enriched uranium than needed for defense purposes. In addition, there are currently few economic incentives to recover plutonium (highly enriched uranium has economic value because it can be blended down so that it is not usable in nuclear weapons and then sold for commercial reactors). Correspondingly, the fissile material assurance programs at some DOE sites have suffered because they lacked support from operations, which no longer have the operational or production incentives to track fissile materials. Over this same time period, DOE safeguards and security programs have focused on applying physical security measures (the "guns, gates, and guards" approach) to mitigate acknowledged weaknesses in fissile material assurance, particularly as many materials were placed in vaults when operations slowed. These factors led to fissile material assurance being perceived as less important, and thus receiving fewer of DOE's resources.

DOE has hundreds of kilograms of unmeasured or poorly measured fissile materials.

Currently, DOE has hundreds of kilograms of fissile materials in the form of scrap, waste, and holdup that do not have defensible measurements. Most of these materials are located at the DOE sites that produced and processed nuclear materials, such as the Hanford Site, the Rocky Flats Environmental Technology Site, the Y-12 Plant, Idaho National Engineering and Environmental Laboratory, and the Savannah River Site. A significant number of items without defensible measurements are also located at various DOE national laboratories, such as Los Alamos National Laboratory and Lawrence Livermore National Laboratory. Significant amounts of holdup are found at the DOE gaseous diffusion plant at Portsmouth, Ohio, which has been leased to the United States Enrichment Corporation (USEC), and a shutdown gaseous diffusion plant at Oak Ridge, Tennessee.

3.0 Results

Progress Since 1995 Oversight Report

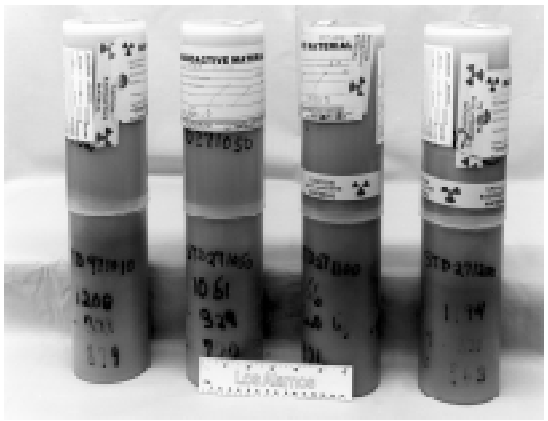
In the three years since the 1995 Office of Oversight special study, a number of significant actions have been taken to improve fissile material assurance. The actions include both complex-wide efforts, such as the MAP, and site-specific efforts.

DOE's measurement assessment project (MAP) provides a baseline of un-measured and poorly measured materials.

From a complex-wide perspective, the most notable achievement is the MAP, which was performed primarily by the FMAWG at the direction of the Secretary of Energy. The MAP involved a systematic assessment of the adequacy of measurements for DOE fissile materials, and has prompted sites to identify their unmeasured and poorly-measured materials. This effort provides a foundation for developing plans to ensure that DOE has defensible measurements and accounting records for all materials, and provides a baseline for tracking improvements. Although there are still some aspects of the assessment that need refinement, the MAP has significantly improved DOE's ability to characterize the adequacy of measurements and provided a much better understanding of the problems that need to be dealt with.

The FMAWG was instrumental in the performance of the MAP and has provided a good forum for discussion of important fissile material assurance issues. The FMAWG has also helped to enhance communications between material control and accountability (MC&A) personnel at various DOE sites and briefed senior DOE managers about fissile material assurance issues. In addition, the FMAWG has worked with the NN on a variety of ongoing Headquarters initiatives. For example, DOE has addressed previously identified problems with an excessive number of unresolved differences between shippers' records and receivers' records. DOE is also modifying the national nuclear material data base to improve DOE's ability to reconcile discrepancies in data bases of waste materials.

Another ongoing initiative is a DOE-wide study, performed by New Brunswick Laboratory, that is evaluating the need for additional measurement standards. This study is intended to address problems with certain materials at a number of sites that cannot currently be measured adequately because there are no adequate standards. In addition, DOE has taken steps to ensure that adequate information is available about software used for various measurement equipment. Specifically, Los Alamos National Laboratory has created training programs and established a "home page" for non-destructive assay (NDA) equipment that enables information to be disseminated readily and improves communications between the software developers and users.



A set of uranium oxide measurement standards used to calibrate non-destructive assay instruments

Some sites have made notable progress in addressing some fissile material assurance issues.

In addition to the complex-wide efforts, various DOE sites have also made some progress in addressing site-specific issues (see text box on page 12). These efforts have addressed some longstanding concerns and reflect the increased attention to fissile material assurance over the past few years. While there is still a long way to go, the efforts at Rocky Flats are notable, considering the historical weaknesses in the MC&A program at that site and the substantial challenges associated with its ongoing efforts to measure large quantities of poorly measured fissile materials. Rocky Flats has stabilized many plutonium items and thus removed a significant barrier to performing the required inventories and measurements (i.e., concerns associated with handling unstable materials have been addressed). As a result, they have completed baseline physical inventories and are meeting approved inventory frequency requirements. It is also notable that the Savannah River Site has completed measurements on most of its poorly measured materials, and the Y-12 Plant has developed a detailed plan to address its large quantities of poorly measured materials, most of which it received from other sites.

Through various site-specific purchases and cooperative efforts between sites, DOE has substantially enhanced its ability to perform measurements. Collectively, DOE sites have invested more than $20 million in additional measurement equipment in the past few years.

The net effect of these accomplishments is that DOE sites have improved their capability to measure materials. DOE sites are also addressing some of the remaining technical obstacles to improving fissile material assurance, such as problems in handling unstable materials and the lack of standards.

Current Status of Fissile Material Assurance

Despite the notable progress at some sites, there is a long way to go before DOE achieves the necessary levels of fissile material assurance. Many of the conditions identified in the 1995 Oversight report persist today. Most notably, there are still hundreds of kilograms of uranium and plutonium in items (e.g., scrap) that do not have defensible inventory values. Even with increased and sustained attention, establishing adequate fissile material assurance will take several years because of the large number of items that need to be accurately measured and the obstacles to performing the necessary measurements (e.g., some materials cannot be measured until they are processed into a measurable form, there are safety issues and radiation exposure associated with handling some materials, and adequate measurement standards are lacking for some materials).

Overall progress to address identified fissile material assurance weaknesses has been slow.

Although some improvements in fissile material assurance are evident, the overall progress toward improving fissile material assurance has been slow. The FMAWG's MAP was the first ever characterization of the status of the DOE's fissile material inventory from a measurement perspective. While it was generally a positive initiative, it was slow to get started and took more time than was necessary because of ineffective communications in the early stages. The MAP provided a good initial assessment of the measurement status and a basis for planning and establishing priorities, however, it should be refined and updated. There are still some materials that are not adequately characterized, and some materials are reported as having good measurements that do not. For example, one site listed materials that were measured before 1965 and had unknown measurement uncertainties as "good" measurements. Another site listed unstable material (plutonium metal and oxides) as having "good" measurements because the materials were listed in a disposition plan, even though that plan had not been fully implemented. Additional refinements of the MAP data could further improve DOE's ability to accurately characterize materials.

One outcome of the MAP is that the sites have all presented plans to the FMAWG that describe how they intend to address the issues of unmeasured and poorly measured materials at their facilities. However, with the exception of the plan for Y-12 Plant, none of the plans are formally documented nor have they been adequately

coordinated within the contractor organization and supported by contractor management and the operations office. Because there are no milestones identified, there is no accountability for meeting commitments. Neither the operations offices nor Headquarters has prioritized proposed measurement activities to provide resources where they are most needed. The Y-12 plan is the only plan that has been submitted to Headquarters for review and approval (September 1997), and it is still under review at Headquarters.

Only a few sites have achieved a significant reduction in their unmeasured materials.

More importantly, few sites have moved past the planning and characterization stage and actually implemented their plans. With some exceptions, such as the Idaho National Engineering and Environmental Laboratory, the Savannah River Site, and the Rocky Flats Environmental Technology Site, few sites have performed sufficient measurements to significantly reduce their inventories of unmeasured or poorly measured fissile materials. It is recognized that improving fissile material assurance is a long-term effort and that effective planning and characterization are necessary steps. However, the efforts to date have not been timely or sustained, resulting in inconsistent progress toward addressing known weaknesses.

An analysis of the Office of Oversight site profiles indicates that about half of DOE sites with significant quantities of fissile material have fissile material assurance weaknesses or important issues to resolve. The general types of weaknesses prevalent at DOE sites include:

- Significant quantities of fissile materials that have never been measured
- Inventory values that are not defensible because the measurement techniques were inadequate or not repeatable, or there are no validated and documented uncertainties, or because the inventory value is based on an estimate (e.g., sometimes estimates were made based on a visual inspection)
- Materials that have indefensible inventory values because of inadequate or lost records (e.g., equipment calibration records)
- Items that cannot be measured because they are inaccessible (e.g., in a high-radiation area, collocated with irradiated materials)
- Failure to conduct required physical inventories, or to establish appropriate compensatory measures when inventories cannot be conducted because of safety concerns
- Physical inventories that do not encompass all materials or that do not provide sufficient data to determine whether materials are accounted for
- Inventory measurements that do not provide assurance that materials have not been diverted (confirmation measurements that are not sufficient for the type of material, confirmation measurements on items that do not have defensible values and that require a quantitative verification measurement, not performing adequate confirmation measurements on materials that are not amenable to quantitative measurement, and poor-quality measurements)
- Inappropriate inventory practices, such as not adjusting accounting records when inventory measurement results indicate significant differences between the inventory measurement result and the established inventory value, and reporting inventory results

Measurements of holdup at the Rocky Flats site. (The yellowish substance on the equipment is fire-retardant paint that is applied to enhance safety.)

SITE-SPECIFIC ACCOMPLISHMENTS TOWARD ENHANCING FISSILE MATERIAL ASSURANCE

Measurements

- The Savannah River Site has completed measurements of most of its previously unmeasured material.
- The Portsmouth Gaseous Diffusion Plant has measured its highly enriched uranium holdup and is currently performing additional monitoring to assure that all areas containing highly enriched uranium holdup have been identified.
- Rocky Flats has validated its ductwork holdup measurements with measurements of the materials recovered when the ducts were cleaned out.
- The Idaho National Engineering and Environmental Laboratory has nearly completed measurements of the process materials associated with a significant operation (i.e., the "Rover" materials).

Material Consolidation and Stabilization

- Significant nuclear material consolidation efforts have taken place at the Idaho National Engineering and Environmental Laboratory, Sandia National Laboratories, Rocky Flats, and Savannah River.
- Rocky Flats has shipped one type of material (highly enriched uranyl nitrate solutions) to a commercial facility to be processed and measured, and has brushed and stabilized oxide from a large number of plutonium buttons; these actions are removing longstanding obstacles to performing physical inventories.

Equipment and Standards

- Lawrence Livermore National Laboratory has obtained a multiplicity counter to measure uranium metal; however, they still need uranium metal standards to calibrate the system.
- Rocky Flats has purchased and installed new NDA measurement equipment, including air bath calorimeters; several other instruments are scheduled to be obtained and installed this year.
- The Pantex Plant is using technical specialists from Brookhaven National Laboratory and the Y-12 Site to evaluate measurement systems used to confirm the presence of uranium in some types of nuclear weapons systems.

Inventories

- Physical inventories have resumed at the Y-12 Plant in all but five of the material balance areas where nuclear operations were discontinued for safety reasons in 1994. The remaining inventories are scheduled to resume during 1999 with the resumption of enriched uranium processing and recovery operations.
- Rocky Flats has completed the baseline physical inventory and is conducting regular physical inventories on approved frequencies.
- The Portsmouth Gaseous Diffusion Plant performs regular "sweeps" to ensure that there is no fissile material in containers or disassembled equipment.

Planning

- A formal plan has been developed for measuring the unmeasured Central Scrap Management Organization materials at the Y-12 Plant.
- Rocky Flats has developed a plan for implementing a new accounting system (RockMas) that is built around the new DOE-standard LANMAS accounting engine.
- Sandia National Laboratories has identified and prioritized its measurement needs so that funding can be addressed and has implemented a new computer-based accounting system.
- Rocky Flats has reviewed nuclear material values contained in its accounting data base and identified those that are indefensible and need to be remeasured; a plan to remeasure these items has been established.

to the DOE materials management data base—Nuclear Materials Management and Safeguard System (NMMSS)—before inventory measurements have been completed

- Incomplete or inappropriate inventory sampling plans (e.g., inappropriate populations, inadequate definition of inventory populations and defects, failure to specify actions to take when there is a defect in the sample, and non-random samples)

- Failure to include holdup in accountability records after it has been identified and/or measured.

Weaknesses noted are similar to those noted in the 1995 Oversight report.

The weaknesses noted above are similar to those identified in the 1995 Oversight report. These continuing, recurring weaknesses indicate that efforts to address identified weaknesses have not been consistently effective at all DOE sites, and that renewed and increased attention is needed.

Two aspects of these weaknesses require additional discussion to reflect events and trends that have become evident since the 1995 Oversight report was issued. Specifically:

- **Continued and recurring weaknesses in physical inventories.** In its 1996 report, the DOE Inspector General criticized DOE sites for their failure to conduct inventories or to ensure that suitable compensatory measures were developed and approved if legitimate safety issues precluded a complete physical inventory. One of those sites, the Y-12 Plant, has not performed complete inventories for more than four years (although progress has been made and physical inventories have resumed in most areas of the Y-12 Plant). In recent months, contractor management at two DOE sites (the Lawrence Livermore National Laboratory special nuclear materials facility, and the Hanford plutonium finishing plant) decided to curtail operations to address safety issues but did not make arrangements to perform the required physical inventories or develop and implement adequate compensatory measures. These recent failures to perform inventories highlight the fact that DOE has not adequately addressed issues related to meeting fissile material assurance requirements during a safety shutdown. Consequently, DOE is still vulnerable to the criticisms cited in the Inspector General's 1996 report. In most instances where operations were curtailed, site management directed a blanket curtailment of operations without formally analyzing the safeguards and security risks. In the case of Hanford, subsequent events demonstrate that it was not absolutely necessary to cancel all portions of a required physical inventory even though operations had been curtailed (i.e., the site conducted a physical inventory of the materials under IAEA safeguards).

Technique for measuring holdup in piping and ductwork

- **Problems with accounting for holdup.** In the 1995 Office of Oversight study, holdup was identified as one of the most significant fissile material assurance issues. Several sites had no valid measurements of the amount of holdup at their facilities, and accounting practices were inconsistent and sometimes inadequate. Some DOE sites have addressed some aspects of this issue by performing measurements to locate and quantify holdup; however, these efforts have not been thorough enough at some sites. In some cases, materials have not been identified (e.g., via wall-to-wall inventories) or adequately measured to determine the amounts of holdup (recognizing that holdup measurements are subject to significant uncertainty). In addition, at least two DOE sites have substantial amounts of holdup that

have been identified but that are not properly reflected in DOE inventory records; the Portsmouth Gaseous Diffusion Plant has located and measured approximately 625 kilograms of highly enriched uranium but has not adequately "booked" the holdup in the permanent inventory records, and Rocky Flats Environmental Technology Site has about 25 kilograms of plutonium that has been identified but not measured or booked.

These two issues are discussed in more detail in Appendix A under Issues A-1 and A-2 respectively.

Risks and Impacts of Weaknesses in Fissile Material Assurance

The weaknesses in fissile material assurance, although significant, do not necessarily result in unacceptable short-term risks if the other elements of DOE's defense-in-depth protection strategy are functioning effectively. The 1995 Oversight report concluded that there was low risk of theft or diversion of strategic quantities of special nuclear material; DOE sites generally had good barriers, alarm systems, protective forces, and materials controls (e.g., two-person rules for material surveillance, tamper-indicating devices on containers, and daily administrative checks). Since then, however, there have been significant cutbacks in the security programs at most DOE sites, including reductions in the number of protective force personnel and elimination of some access control points.

DOE is performing more activities involving movement of nuclear materials.

In addition, many DOE facilities are undertaking increased operations involving fissile materials and thus have a need for better fissile material assurance programs. In 1995, most DOE fissile operations were shut down: few sites had ongoing operations that involved processing fissile materials, and most of DOE's fissile material was locked in vaults and rarely accessed. Now, DOE has consolidated the weapons complex operations and is performing more activities related to the national defense program, such as weapons disassembly and refurbishment. In support of these efforts, there is increased activity involving fissile materials at a few sites (e.g., Los Alamos National Laboratory), and the Y-12 Plant is restarting operations to support Defense Programs efforts. In addition, in 1995, most of DOE's D&D and environmental restoration efforts at major fissile materials sites were in the planning stage. Today, many DOE sites are undergoing active D&D efforts, which involve moving and processing fissile materials to stabilize and repackage them for removal from shutdown facilities and placing them in long-term storage.

The combination of security cutbacks and increased fissile material operations has posed additional challenges to both fissile material assurance and physical protection. The Office of Oversight site profile effort determined that, in most cases, DOE sites had adequately managed the cutbacks and were operating more efficiently but with a lower margin for error. The conclusion of the site profile effort was that no sites had special nuclear material at immediate risk. However, several sites, including Rocky Flats, Lawrence Livermore National Laboratory, and Los Alamos National Laboratory, required immediate compensatory measures and prompt attention to correct identified deficiencies. Before compensatory measures were implemented at these sites, there were times when the physical protection was less robust than desired. A concurrent review by NN reached very similar conclusions.

At the sites noted as requiring prompt attention in the Oversight site profiles and the NN review, some aspects of their fissile material assurance programs are deficient. Although there is no indication of theft or diversion of material at these sites (or any other DOE sites), their current level of fissile material assurance is not sufficient to demonstrate conclusively that all materials are accounted for.

Effective fissile material assurance programs are the only conclusive way to demonstrate that physical protection has been effective.

In light of the reductions in security and the increased operations involving fissile materials, DOE can no longer afford to rely on physical protection measures to compensate for acknowledged weaknesses in fissile material assurance. The importance of fissile material assurance is increasing as DOE sites need to be able to demonstrate that their protection measures are effective. Effective fissile material assurance programs are the only conclusive way to prove that all fissile materials are accounted for. Further, without effective fissile material assurance, DOE sites cannot adequately perform emergency inventories, conclusively resolve inventory differences, and reliably detect a protracted diversion of fissile materials.

Based on the site profile effort and other reviews, Oversight continues to believe that the risk of theft and diversion of a significant quantity of fissile material is low at DOE facilities. However, fissile material assurance is not yet adequate to meet other safeguards objectives, and the plans for improvement have not been adequately reviewed and formalized.

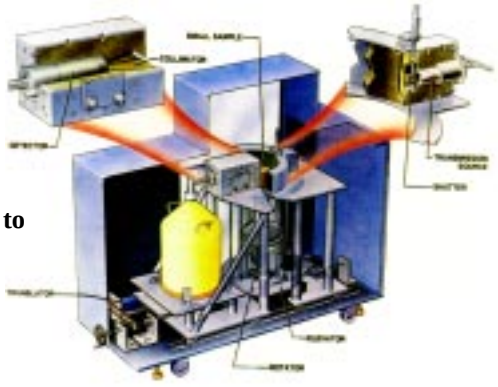
In addition to the safeguards impacts, a number of factors call for accelerating the efforts to improve fissile material assurance. These factors include the increased amounts of excess fissile materials being offered for IAEA inspection, the potential transition to regulation by the U.S. Nuclear Regulatory Commission (NRC), ongoing transfers of fissile materials to the USEC, and interfaces between fissile material assurance and ES&H.

Weaknesses in fissile material assurance will make a transition to NRC regulation or meeting the U.S. commitments to offer fissile materials to the IAEA for inspection expensive and difficult.

Because of the differences in the requirements and weaknesses in DOE fissile material assurance programs, a transition of a DOE facility from DOE regulation to NRC regulation or offering DOE materials up to IAEA inspection will be difficult and costly. In addition, weaknesses in the U.S. domestic fissile material assurance program could reduce U.S. credibility in the international community, thus limiting DOE's ability to meet Strategic Plan provisions that relate to enhanced international safeguards, nonproliferation, treaties, and bilateral agreements. The Strategic Plan specifies that more than 50 metric tons of highly enriched uranium will be transferred to USEC or offered for IAEA inspection. Such material must have defensible measurements and inventory values. In some cases, establishing inventory values that are acceptable to the IAEA will require processing the material into forms that will support defensible measurements.

Weaknesses in fissile material assurance can also impact ES&H programs, such as radiation protection and criticality safety, which have important interfaces with fissile material assurance programs. For example, criticality safety limits require accurate knowledge of the amount of material in each item; the accountability values for items typically are used to determine the amount of material in each item. Discrepancies in accountability values could contribute to a criticality safety limit violation and, in the worst case, a criticality event that causes fatalities or injuries.

Appendix B discusses in detail the potential impacts of weaknesses in fissile material assurance on DOE's ability to meet provisions of the DOE Strategic Plan, including provisions related to ES&H and the transition of DOE materials to IAEA, USEC, and/or NRC.



A segmented gamma-ray scanner is used to scan containers of nuclear waste to determine the amounts of fissile materials within the containers.

Obstacles to Improving Fissile Material Assurance

In the early years of the DOE nuclear program, limitations in measurements technology posed a major barrier to accurately accounting for fissile materials. Advances in measurement technology in the past 20 years have greatly increased the ability to accurately measure legacy fissile materials. For example, the development of NDA instrumentation provided the capability to measure many types of materials, such as waste, that could not be measured at the time they were produced. Measurement technology has progressed to the point where it is even possible to perform credible measurements of fissile materials contained in many holdup configurations. A few types of materials, such as irradiated fuels and nuclear weapons systems, are still difficult or impossible to measure with current technology.

In recent years, DOE sites have taken steps to address some of the remaining technical obstacles to improving fissile material assurance, including obtaining the equipment needed to perform measurements. As discussed under Issue A-3 in Appendix A, the lack of suitable equipment and measurement standards continues to be an obstacle at some sites for some types of materials. However, DOE initiatives, such as an ongoing study of the need for additional standards by the New Brunswick Laboratory, have the potential to address many of the remaining technical obstacles to performing measurements.

The wide range of shapes and sizes of scrap and waste containers poses challenges to developing suitable measurement standards.

It is technically feasible to measure most fissile materials, but a number of obstacles remain.

Thus, it is **technically feasible** to adequately measure most materials in DOE's possession using existing technology. However, there are a number of obstacles that continue to hinder DOE site efforts to perform measurements and improve fissile material assurance programs in a timely manner. These obstacles can be characterized as (1) safety/operations, (2) policy/regulation, and (3) program management.

Safety/Operations Obstacles

As discussed previously, DOE sites have failed to perform required physical inventories because of safety-related shutdowns. In addition, there are a number of instances where DOE sites do not perform measurements because the materials are difficult or dangerous to handle (e.g., highly or moderately irradiated, unstable, or pyrophoric). Further, some materials are located in areas where radiation levels are high, thus causing personnel who handle or measure them to receive significant radiation exposures. In addition to safety-related concerns, some fissile materials cannot be adequately measured until they are processed into a measurable form, and in some cases, the facilities needed to process the materials are shut down for operational, safety, or environmental reasons.

Safety and operational obstacles have not been adequately analyzed.

These conditions, which are essentially the same as those reported in the 1995 Oversight report, are significant obstacles that are not easily overcome. Nonetheless, as discussed under Issue A-3 in Appendix A, most facilities have not yet even begun to analyze these obstacles or made realistic plans to address them. Consequently, DOE's progress toward improving fissile material assurance has been slower than it could have been. In addition, many DOE sites are not achieving the synergistic benefits of close coordination

between MC&A and other facility organizations, such as criticality safety (discussed in more detail in Appendix B).

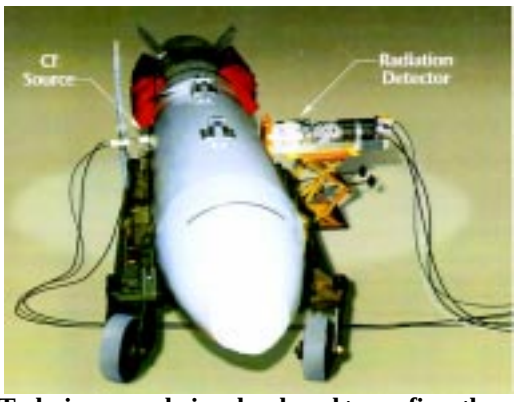
Policy/Regulation Obstacles

A common thread throughout the issues in this Oversight followup report is that policies and guidance have not been reevaluated and revised in response to changing needs. Most DOE MC&A policies were developed during a different era, when DOE was focusing on meeting production goals. The current policy and guidance are more applicable to production facilities and efforts to address the issues encountered today, such as long-term storage, IAEA inspections, D&D, and material stabilization, have been fragmented.

Revisions to the current DOE order governing fissile material assurance have been significantly delayed.

There is a general consensus that the current order governing MC&A, issued in 1994, needs improvement (e.g., some provisions are unnecessarily prescriptive, and others are ambiguous). A revision addressing some of the needed changes has been drafted and revised several times. More than a year after it was considered a priority effort, the revised draft order has not been sent out for formal comment. The underlying factor appears to be that the MC&A community is unable to agree about certain provisions of the revised order, so a virtual stalemate has developed. Although there are legitimate differences among professionals that are difficult to reconcile, the current stalemate is delaying other changes that are generally viewed favorably by all parties, forcing sites to implement certain prescriptive provisions for which less expensive alternatives may be available. A related concern is that disagreements over policies are contributing to a growing trend to tolerate non-compliance with DOE order provisions at DOE sites and operations offices. (Issue A-4 in Appendix A provides more detail on problems associated with DOE order revisions and non-compliance.)

A thorough revision of DOE policies and guidance can help resolve obstacles to progress by clarifying and simplifying the fundamental requirements of a solid MC&A program. A number of specific aspects of policy need to be analyzed and enhanced, including implementation of termination of safeguards policy (see Issue A-5 in Appendix A), policies for irradiated fuel (see Issue A-6 in Appendix A), acceptable compensatory measures when safety issues preclude a full physical inventory, and special issues associated with certain types of materials (e.g., weapons components, mixed oxide fuel elements, and holdup).



Techniques are being developed to confirm the presence of fissile material in nuclear weapon components.

The inability to demonstrate progress toward improving DOE policies and revising applicable orders is not unique to the MC&A community. However, the lack of progress is of particular concern in light of the significant delays (more than three years since the 1995 Oversight report was issued, and almost two years since the FMAWG issued its recommendations) and the fact that there is no indication that the current gridlock will be broken in the near future.

Program Management Obstacles

The quality of plans to address fissile material assurance weaknesses varies considerably, and many plans are not adequate.

By performing the MAP, DOE has made substantial progress toward addressing one major obstacle—inadequate characterization of materials—that has hindered effective program direction. As part of the MAP effort, DOE sites presented site-specific plans for measuring fissile materials that do not currently have defensible values.

While a few sites are performing measurements, many sites have not developed formal plans that can be realistically implemented. For example, plans are not documented; sites do not identify funding mechanisms and resources; few sites have formally coordinated the planned activities with their DOE operations office or program office; and few sites have addressed obstacles, such as radiation exposure, that may be encountered when performing measurements. (See Issue A-3 in Appendix A for additional details on the site-specific plans.)

Because there are so many unmeasured and poorly measured items, it will be time consuming and resource intensive to measure all materials; some sites have hundreds of kilograms of fissile materials in thousands of different items that are not adequately measured. Resources for performing extensive measurements and other fissile material assurance activities are limited, and often funded from overhead accounts. In the competition for resources, fissile material assurance activities have generally received low priority. This low priority has been evident in historical delays in procuring appropriate measuring equipment (although significant progress has been made recently in obtaining equipment), decisions not to perform measurements on legacy materials, decisions to use available equipment for other purposes, delays in developing standards, and similar problems that have contributed to weaknesses in fissile material assurance. Without effective planning and identified resources, there is no assurance that the plans will be funded and implemented.

Inconsistent program direction and line management support is a significant obstacle.

The lack of effective plans to address unmeasured or poorly measured materials and other fissile material assurance weaknesses is symptomatic of longstanding problems with program direction and line management support. While not unique to MC&A, problems with program direction, such as inconsistent direction from multiple sources, slow decision processes, ineffective dispute resolution practices, and lack of a clear decision-making authority, have contributed to the weaknesses in fissile material assurance and to the slow progress to correct them. In addition, DOE sites have a pronounced tendency to place too much reliance on physical protection measures to mitigate weaknesses in fissile material assurance. (See Issue A-7 in Appendix A.)

Establishing the FMAWG has been a positive step toward improving program direction. The FMAWG consists of knowledgeable, experienced, and dedicated people who are genuinely interested in making improvements. It has provided a good mechanism for the field to raise issues and a good forum for discussion between NN and the field. The FMAWG has also provided value to DOE by helping to perform the MAP and identifying policy issues. However, the FMAWG is only partially achieving its objectives. Specifically, the FMAWG is not addressing all of its responsibilities, and its efforts have not led to timely resolution of issues. The slow progress is contributing to waning enthusiasm for participation in FMAWG activities by some field personnel. (See Issue A-8 for additional discussion on FMAWG activities and program direction.)

The most important factor to be addressed is inconsistent line management support.

The single most important factor requiring attention is inconsistent support from line management (including the program office, the operations office, and contractor management). Progress toward resolving fissile material assurance issues requires a concerted and sustained effort and cannot be accomplished by MC&A staff alone. Line management support is essential to resolve issues, ensure that resources are applied to fissile material assurance, and ensure close coordination between MC&A personnel and ES&H, production, and measurements personnel. The experience with the MAP demonstrates that line management support is necessary to make progress on fissile material assurance issues—the MAP received priority at DOE sites and made substantial progress only after a senior DOE Headquarters manager (EM-1) was assigned responsibility for the effort. Further, management support for fissile material assurance issues has been inconsistent at some sites, as evidenced by the failures to conduct inventories, insufficient support for fissile material assurance measurement plans, and a low priority for MC&A programs. The needed improvements in fissile material assurance will not occur unless DOE takes action to ensure that line management is actively involved in fissile material assurance issues and accountable for achieving improvements.

4.0 Opportunities for Improvement

While some progress has been made in resolving fissile material assurance issues and some sites are effectively addressing fissile material assurance issues, the overall conclusion of this followup review is that progress has been slow and efforts to improve are losing momentum. The following opportunities for improvement are not intended to be prescriptive. Rather, they are intended to provide DOE Headquarters and the field with a framework for enhancing fissile material assurance programs and resolving some of the obstacles to success.

The first four opportunities for improvement are site-specific and are best addressed by individual sites and operations offices. For each of the opportunities for improvement, the sites and organizations that are most directly affected are identified in parentheses. The last four opportunities for improvements are DOE-wide and will require attention and action at DOE Headquarters.

1. Resolve issues that have led to failures to conduct required physical inventories of nuclear materials at several DOE sites. (Hanford Site, Lawrence Livermore National Laboratory, and the Y-12 Plant)

DOE has not adequately addressed the underlying factors that have resulted in the repeated failures to conduct required inventories or ensure that suitable compensatory measures were implemented. To prevent recurrences of this situation:

- The cognizant program offices (Defense Programs and EM) and operations offices (Oakland, Richland, and Oak Ridge) need to ensure that Lawrence Livermore, Hanford, and the Y-12 Plant resume physical inventories as soon as possible.

- NN and the FMAWG need to cooperatively develop and issue formal guidance for establishing suitable compensatory measures to be used when a physical inventory cannot be performed because of operational curtailments and/or safety shutdowns. The guidance should specify that sites complete as much of the physical inventory as possible—too often sites cancel or delay an entire physical inventory when only a portion of the facility is affected by safety issues.

- Interim policies should be developed and eventually incorporated into DOE orders, requiring sites to develop and implement suitable compensatory measures when a required physical inventory cannot be performed. Prompt notification of the responsible operations office and program office and NN should also be required whenever an inventory is significantly delayed.

2. Ensure that holdup is identified, measured, and properly reflected in the inventory records, and that inventory records are updated as appropriate. (Rocky Flats Environmental Technology Site and Portsmouth Gaseous Diffusion Plant)

Several DOE sites that have holdup that cannot be readily removed need to consider additional actions to address weaknesses in their identification and measurement of holdup:

- The Oak Ridge Operations Office and the Portsmouth Gaseous Diffusion Plant need to:
  - Take prompt action to ensure that holdup in the cascade facility is properly reflected in inventory records.
  - Ensure that holdup is properly categorized and protected until it can be removed.
  - Identify and evaluate options to accelerate removal of the largest identified accumulations of highly enriched uranium from cascade equipment. Such removals may also benefit criticality safety and radiation protection efforts and may support reductions in security costs.
  - Verify that the interfaces between the DOE contractor and USEC contractors are effective in ensuring that DOE materials are properly accounted for and protected, with particular attention to activities that involve disassembly or removal of equipment (which could result in holdup becoming accessible).
  - Coordinate as needed with NRC and USEC to ensure that issues involving highly enriched uranium holdup in leased facilities and equipment are addressed (the NRC certificate for operations does not encompass highly enriched uranium).
- The Rocky Flats Field Office and the Rocky Flats Environmental Technology Site need to formalize their approach to the holdup efforts, ensure that holdup is properly measured and booked when it is identified, and validate holdup measurements when holdup is recovered from process equipment.

3. Ensure a timely and coordinated review and decision by Defense Programs on the Y-12 Plant plan for measuring fissile materials. (Y-12 Plant, Oak Ridge Operations Office, and Defense Programs)

The Y-12 Plant measurement plan is comprehensive and has been effectively coordinated between the contractor and Oak Ridge Operations Office, including identification of funding needed to perform measurements. It has also been reviewed by the FMAWG and modified accordingly. However, there are indications that the Defense Programs (DP) review of the Y-12 Plant plan may involve several separate iterations by different DP organizational elements and is taking an extended time. DP and the Oak Ridge Operations Office need to:

- Streamline the DP review process to ensure a timely decision with a minimal number of iterations.
- Approve the plan and funding or develop a timely alternative that ensures timely efforts to improve measurements and that addresses the large quantities of materials at the Y-12 Plant, the long operational curtailment, additional materials shipped to Y-12 in recent years, and the ongoing restart of operations (which entails resuming processes that require accurate knowledge of quantities of materials).

4. Accelerate efforts to develop and implement effective and realistic site-specific plans for addressing fissile material assurance weaknesses, including an assessment of impacts on DOE's ability to meet provisions of the DOE Strategic Plan. (All sites should examine their ability to meet the DOE Strategic Plan provisions. Particular attention to measurement plans is needed at Rocky Flats Environmental Technology Site, Los Alamos National Laboratory, Lawrence Livermore National Laboratory, the Hanford Site, and Argonne National Laboratory-West.)

DOE needs to take a more active role in ensuring that measurement plans are developed, coordinated, approved, and implemented. In addition, the scope of the plans should be expanded to address other aspects of fissile material assurance (physical inventory, for example) and to ensure that weaknesses in fissile material assurance do not impact DOE's ability to meet the provisions of its Strategic Plan. To this end, DOE should consider:

- Increasing the operations office involvement to ensure that the plans identify priorities and realistic milestones, and that the necessary resources are identified and allocated.

- Ensuring that DOE senior managers hold operations office and program offices accountable for establishing realistic plans and milestones for meeting fissile material assurance objectives.

- Requiring each program office to provide regular briefings to the Security Management Council (which is led by the Deputy Secretary and is chartered to address and resolve the major issues affecting the DOE's safeguards and security programs) on the status of measurement plans and progress toward achieving established milestones.

- Having FM-1 take a more active role in establishing plans and monitoring and reporting progress.

- Systematically analyzing whether weaknesses in fissile material assurance can significantly impact DOE's ability to meet strategic goals, including goals related to safeguards and security, non-proliferation, ES&H, and facility management. Such impacts need to be understood and incorporated into site plans. An analysis of fissile material assurance issues against the Strategic Plan may also provide a useful and defensible basis for determining safeguards priorities. The FMAWG is well positioned to provide support to such efforts and to analyze impacts and priorities from a DOE-wide perspective since many of the key decisions cannot be made on an individual site basis (such as selecting materials to be included in the 26 metric tons that are slated to be offered up to inspection by the IAEA).

- Establishing processes to ensure adequate reviews of site-specific plans as well as timely decisions on approval and funding.

5. Enhance management support for fissile material assurance by ensuring that program offices, operations offices, and contractors are accountable for progress.

DOE needs to establish better mechanisms for ensuring that program offices, operations offices, and contractors place appropriate priority on fissile material assurance issues, that plans have clear milestones and are implemented on schedule, and that line management is accountable for results. Such mechanisms could include:

- Establishing a process to track and monitor FMAWG recommendations. Such a process could include having the Security Management Council review and accept/modify/reject FMAWG recommendations and monitor

progress to ensure that the program offices, operations offices, and contractors achieve adequate results in a timely manner. The Security Management Council already has responsibility for monitoring safeguards and security improvements, so the interface with FMAWG is a natural fit. The Security Management Council also has the necessary level of authority to ensure that FMAWG recommendations are appropriately coordinated with line management and, if accepted, to ensure that they are implemented.

- Reviewing contracts, contractual performance objectives, and objective measures of performance to ensure that disincentives to effective fissile material assurance performance are eliminated. For example, there have been a few instances where contractors had incentives to remove radioactive materials from a facility by a certain date but did not have provisions to ensure that fissile material assurance objectives were met before doing so. This has led to instances where fissile materials were removed from a secure facility but later had to be returned to a secure facility when the safeguards implications were realized.

- Including performance objectives and performance measures related to fissile material assurance in management and operating contracts and management and integration contracts. Effective contract incentives (rewards and sanctions) can focus management attention, ensure accountability for results, and promote efficient use of resources. Contract closeout clauses could also include provisions for withholding fee or similar sanctions, pending completion of an inventory. Some fissile material assurance activities may require incremental funding; however, many of the needed measurements can be performed with in-house resources if contractor senior management ensures that those efforts are a site priority and if appropriate contractual performance rewards are used as an incentive to perform effectively and efficiently.

- Establishing specific and measurable provisions for achieving fissile material assurance objectives and measurement plan milestones in the DOE Strategic Plan and performance agreements with each of the DOE business lines.

- Ensuring that the above-mentioned fissile material assurance provisions flow down from the program office to the operations office manager and associate managers and subsequently to MC&A staff, and that such provisions are incorporated into performance evaluations.

- Assigning a DOE manager, such as the Deputy Secretary for Field Management (FM-1), or a senior staff member in the Deputy Secretary's office, to monitor progress toward addressing fissile material assurance issues and report regularly to the Deputy Secretary on the status. As needed, FM-1 could ensure that the field's views are adequately represented, encourage line management to support fissile material assurance activities, participate in FMAWG briefings, and act as an advocate for fissile material assurance issues at Headquarters.

6. Enhance fissile material assurance program direction by strengthening and expanding the role of the FMAWG and increasing coordination with the DOE Security Management Council.

DOE continues to have a need for a group such as the FMAWG to provide program direction, apply technical expertise, suggest improvements to policy for consideration by the MC&A Quality Panel (which works with NN to develop and clarify polices), and ensure that field perspectives are represented in the Headquarters decision-making process. To improve program direction, DOE senior managers should consider taking actions to strengthen and expand the role of the FMAWG:

- Assign the FMAWG the responsibility to monitor the field's development of plans to address fissile material assurance weaknesses as discussed above. The FMAWG's role should include working with sites to refine MAP data, providing and clarifying guidance for the development of such plans, reviewing the products, providing feedback to the field, promoting consistency where appropriate between sites, coordinating issues that affect multiple sites, and ensuring that the plans meet DOE objectives.

- Strengthen the FMAWG's role in ongoing DOE efforts to enhance communications, ensure that efforts are coordinated, and increase visibility and support for fissile material assurance. For example, the FMAWG should play a stronger role in ongoing DOE efforts to determine the ultimate disposition of excess fissile materials and facilities.

- Have the FMAWG provide regular briefings to the Security Management Council. The Security Management Council committee should also consider using the FMAWG as a technical resource as complex issues arise involving fissile material assurance. In addition, the FMAWG could be used to provide support and advice to the Security Management Council in evaluating recommendations made by the Special Review Team (led by Sandia National Laboratories personnel) assessment of safeguards and security technology to protect sites. In addition, the FMAWG could be used to provide support and advice to the Security Management Council in evaluating Special Review Team recommendations.

- Identify methods to improve timeliness of FMAWG efforts. Currently, most FMAWG personnel only have the opportunity to contribute to FMAWG efforts at meetings, which typically are held once per quarter. Timeliness could be enhanced by increased communication and continuation of efforts between meetings, and by increased use of subcommittees.

- Ensure that line management (program offices, operations offices, and contractors) recognize that FMAWG efforts have senior management support and are a DOE priority. Line management can promote more timely progress by allowing more opportunity for operations office and contractor MC&A personnel to contribute to FMAWG efforts between the scheduled meetings. Line management can also promote progress by ensuring that their sites are responsive to FMAWG requests for information.

- Strengthen the FMAWG's role with respect to policy development and refinement, including more participation in developing order revisions and policy memoranda. An expanded role in these areas should improve the processes for coordination, review, and approval of orders and revisions, and ensure that field perspectives are incorporated. The FMAWG should also have a prominent role in a baseline reassessment of policy and a comprehensive order rewrite.

- Improve processes to provide information to DOE senior managers, including presentation of alternative views when a consensus position cannot be reached within the FMAWG.

- Coordinate with the New Brunswick Laboratory effort to identify needs for additional measurement standards to ensure that the effort will appropriately address the wide range of materials at DOE sites and the site-specific problems that are hindering site efforts to perform measurements.

- Give the FMAWG an increased role in determining how NN research and development (R&D) and technical support resources (such as NN-funded support at national laboratories) are used. For example, the FMAWG could have an increased role in determining R&D priorities and coordinating development efforts (such as development of LANMAS and enhancements to NMMSS).

The FMAWG should be able to assign tasks to experts from national laboratories and thus make use of laboratory resources to perform tasks, such as evaluating technical issues or developing position papers, in direct support of FMAWG efforts.

- Ensure that the FMAWG is involved in developing a consolidated approach to IAEA and bilateral inspections that is consistent across DOE facilities, that DOE effectively coordinates its efforts to bring inventory values and policies in line with international requirements, and that revisions to DOE orders and guidance reflect consideration of IAEA safeguards and bilateral agreements.

7. Resolve issues that have delayed the review and reissue of the revised DOE order governing MC&A.

Although a baseline review of DOE policies is needed (see following opportunity for improvement), the ongoing efforts to issue a revised order should not be further delayed while a complete rebaselining is undertaken. The changes recommended by the FMAWG are important and should be incorporated into a revised order as soon as possible. NN and the FMAWG need to:

- Accelerate efforts to disseminate the revised order for formal review and comment.

- To the extent possible, develop consensus prior to the formal review while recognizing that the effectiveness of MC&A provisions cannot be compromised simply to achieve a consensus.

- As necessary, identify issues that cannot be resolved and subject them to an issue resolution process.

- Ensure that unresolved issues do not unnecessarily delay issuing revisions to the order; unresolved issues can be addressed through page changes to the order when a final resolution is achieved, if necessary.

8. Perform a baseline reassessment of policy and guidance.

In light of changing conditions and new priorities, a baseline analysis of DOE policies and a comprehensive rewrite of the MC&A order are needed. While certain provisions have been modified to address specific problems, there has not been a comprehensive and systematic analysis of the requirements for a considerable period. A baseline analysis should:

- Specifically recognize the need to ensure the effectiveness and efficiency of fissile material assurance programs for a wide variety of facility conditions and phases of operations, including production, D&D, waste treatment, long-term storage (including international inspections), and reprocessing/recovery. Issues that have seldom been encountered previously, such as measurements of mixed oxide fuels, also need to be evaluated and addressed.

- Determine what changes should be made so that the DOE orders are consistent, where appropriate, with IAEA and/or NRC requirements, since a great deal of DOE's material will eventually be offered up for IAEA inspection and possibly regulated by the NRC. These differences are causing some difficulty as DOE offers fissile materials up for IAEA inspections, and are likely to be a significant impediment to any future transition of DOE sites to NRC regulation.

- Reexamine the roles and responsibilities of various organizations to ensure that appropriate controls are in place and that the MC&A organizations have sufficient involvement in actions with potential safeguards impacts.

- Establish an effective issue resolution process that includes a central authority, such as the Security Management Council, as a final arbiter. Revisions of the DOE order have been delayed because of the inability to resolve complicated and contentious policy issues. An effective issue resolution process needs to have mechanisms to raise issues to higher levels of management when they cannot be resolved within a reasonable time by MC&A specialists.

If effectively implemented, the actions identified above can lead to long-term improvements in both the effectiveness and the efficiency of DOE fissile material assurance programs.

Appendix A

Detailed Discussion of Issues Requiring Attention

ISSUE A-1: Continued and Recurring Weaknesses in Physical Inventories

The Department of Energy (DOE) requires that sites with nuclear materials conduct periodic physical inventories to determine the amount of material on hand and to verify that materials are in their designated locations. As a part of a physical inventory, sites typically perform measurements of a selected sample of items and materials. Physical inventories are an important mechanism for detecting theft or diversion of nuclear materials. They are also important aspects of International Atomic Energy Agency (IAEA) and bilateral agreements. Further, some elements of the safety program, such as criticality safety, rely on nuclear material accountability programs to provide information about the location and amounts of fissile materials.

The April 1996 DOE Inspector General report identified three DOE sites (Y-12 Plant, Rocky Flats, and Idaho National Engineering and Environmental Laboratory) that were not meeting physical inventory requirements. The sites were not performing the required inventories because operations involving nuclear materials had been shut down to address safety issues. The Inspector General report was critical of the conflicting direction that DOE gave the site regarding the need to perform required physical inventories during the operational curtailment, and the failure to request waivers. At Idaho, the contractor resumed physical inventories soon after the Inspector General's findings were issued, and Rocky Flats resumed physical inventories after about a year. At the Y-12 site, the Oak Ridge Operations Office made the decision to not perform the required physical inventories during their safety shutdown, but established some compensatory measures. Y-12 has resumed physical inventories in most (all but five) material balance areas where nuclear operations were discontinued for safety reasons in 1994. The remaining inventories are scheduled to resume during 1999 when all of the enriched uranium operations are resumed.

DOE continues to experience problems with performing physical inventories as required. In the past year, three DOE sites have not performed required physical inventories at facilities with significant special nuclear material: the Lawrence Livermore National Laboratory plutonium facility, and Hanford's plutonium finishing plant. In each of these cases, the safeguards staff were directed not to perform physical inventories because operations were curtailed to address safety issues.

These recent failures to perform inventories highlight the fact that DOE has not adequately addressed issues related to meeting safeguards and security requirements during a safety shutdown. Consequently, DOE is still vulnerable to the criticisms cited in the Inspector General's 1996 report. Safety is a very high priority, and there are times when it may be necessary to curtail operations

at DOE facilities. However, it is evident that safeguards and security issues are not receiving sufficient emphasis in the management decision-making process. In most cases where operations were curtailed, site management directed a blanket curtailment of operations without formally analyzing the safeguards and security risks associated with not performing required inventories and without notifying the DOE Office of Nonproliferation and National Security (NN) or the program offices that they were not going to meet a DOE requirement.

In at least one case, subsequent events demonstrate that it was not absolutely necessary to cancel all portions of a required physical inventory even though operations had been curtailed. Hanford material control and accountability (MC&A) personnel at the plutonium finishing plant were directed not to perform an inventory when operations were curtailed. However, when Hanford management determined that they needed to meet provisions of the IAEA agreements, the site conducted the physical inventory of the materials under IAEA safeguards. Otherwise, this portion of Hanford's physical inventory would not have been performed.

The sequence of events at Hanford demonstrates that management support for safeguards issues and DOE MC&A requirements is not always sufficient to ensure that safeguards requirements are met, particularly when they must be balanced against competing operational or safety requirements. The Hanford situation demonstrates that, given sufficient management priority or external pressure, it is often possible to perform inventories safely even when operations are curtailed. When it is not possible to complete all aspects of a physical inventory, it may be possible to design compensatory measures that can accomplish some of the objectives of the physical inventory. To address this concern, DOE needs to improve coordination between safety and MC&A in resolving issues during safety stand-downs and to ensure that safeguards issues are addressed whenever operations are curtailed. More specifically, DOE should consider controls to ensure that sites do not simply cancel required physical inventories without adequate analysis of the options and without formally notifying appropriate organizations in the operations office (e.g., the safeguards and security organization) and at Headquarters (including NN and the cognizant program office). In those cases where a safety shutdown will cause a significant delay in a physical inventory (e.g., more than a month), it may be appropriate to establish controls that ensure that sites develop adequate compensatory measures that are reviewed by NN and approved by the operations office.

Increased attention is also needed to ensure that sites can effectively perform physical inventories after an extended shutdown. After previous extended shutdowns and periods without physical inventories, DOE has experienced significant problems. For example, in 1985, the PUREX facility at Hanford was scheduled for restart. The plans called for three months of operation, followed by cleanout and physical inventory. However, because of Departmental needs, the facility operated for 12 months. The physical inventory resulted in a significant inventory difference, which necessitated a DOE investigation (which could not ascertain when the inventory difference occurred).

Without careful planning, DOE may be facing a similar situation at the Y-12 Plant. The Y-12 Plant has performed some compensatory measures (e.g., item inventories in some material balance areas) but it has been almost five years since a complete physical inventory was performed. The effectiveness of the interim measures cannot be determined until a complete physical inventory is taken, the material balance is closed, and the resulting inventory difference is evaluated. The plan to restart operations in phases without closing the material balance will make it very difficult to effectively evaluate any inventory difference that occurs (e.g., it will be virtually impossible to isolate the effects of events that happened during the operations stand-down from those that occurred after operations were resumed). Therefore, it may be difficult to verify that material is accounted for and has not been diverted. While restarting the Y-12 Plant operations as soon as possible is considered important to DOE strategic plans, it is also important to ensure that safeguards issues are considered. DOE should consider performing an assessment of the Y-12 Plant restart plans to ensure that reasonable actions are being taken to provide for effective physical inventories and allow reconciliation of inventory differences.

Another issue that needs attention involves materials that are not being included in physical inventories because of a real or perceived loophole in the orders. Specifically, a few DOE sites have nuclear materials that are collocated with irradiated materials. The irradiated materials are not inventoried (because of radiation hazards and lack of methods to perform measurements). However,

the non-irradiated materials are also not being inventoried or included in measurements programs because they are near the irradiated materials and are considered self-protecting by the site when in fact they are not. A careful review of such situations is needed to ensure in each case that the storage of non-irradiated material near irradiated materials is necessary and appropriate. When collocation is necessary, the provisions for physical inventories and measurements need to be reviewed to ensure that they are adequate to meet safeguards objectives.

In some cases, the implementation of physical inventories has been inconsistent and sometimes ineffective:

- **Confirmation measurements are performed on materials that do not have defensible values**. Confirmation measurements are only appropriate when the accounting records have a defensible nuclear material value and the item is maintained under surveillance and sealed with a tamper-indicating device.

- **Measurement techniques used for confirmation measurements are inappropriate for the material and/or conditions**. The types of measurements used for confirmation are often not adequate, given the characteristics of the material contained in the item, the degree of confidence placed in the tamper-indicating device, and the level of surveillance applied to the item. For example, a simple confirmation measurement (e.g., a characteristic gamma signature) may be appropriate for a plutonium metal button that is stored in a vault, sealed with a tamper-indicating device, and subject to stringent material surveillance procedures (e.g., administrative controls and a strict two-person rule). However, a quantitative verification measurement would be needed if the item had not been under surveillance and properly protected since the value was established.

- **Materials listed as "not amenable to measurement" are not measured by two confirmation measurements as required.** In many instances, the only methods used to verify that such materials are present are item identification and location checks. Such methods are not sufficient to detect diversion or substitution and do not meet the applicable requirements.

- **Significant differences between verification measurement results and the inventory values are not resulting in new inventory values.** When a physical inventory is conducted, verification measurement results are compared to the inventory record values. When there is a significant difference (i.e., greater than an established accept/reject criteria), the situation must be resolved by entering a new value in the accounting system. This is not being done at some sites. In some cases, the inventory value is not changed because the original measurement method is thought to be very good even though it can't be defended (there are no valid or documented measurement uncertainties, the measurement method is not documented, and the measurement cannot be repeated). When the original inventory value cannot be verified and the value is not defensible, a new inventory value must be established even if the original measurement result is thought to be more precise than is now possible. The purpose of verifying inventory values is to validate the accounting records and to detect theft or diversion. If such a situation as has been described is ignored, a basic tenet of physical inventories has been violated.

- **Inventory measurements are not being completed before the inventory is reported to the Nuclear Materials Management and Safeguards System (NMMSS).** Closing out a physical inventory before completing all of the inventory measurements is an unacceptable practice that was observed at two national laboratories during the site profile visits. In both cases, the facility had reported the inventory to NMMSS but had not performed the verification/confirmation measurements to complete the inventory.

- **The approach to statistical sampling during physical inventories is not sufficient to provide confidence that fissile materials are accounted for**. To draw valid conclusions from an inventory sample, it is necessary to select items at random and to ensure that all items are appropriately included in the population that is sampled. In many cases, the site sampling methods are not adequate to address common situations, such as items that are selected but that cannot be safely moved or measured. In addition, there are no specific requirements to select a sample size that provides an adequate level of confidence, and some sites do not select enough items to provide adequate confidence in the results. Such weaknesses can result in questionable or invalid inventory statements. On the other hand, the appropriate use of valid statistical sampling techniques may not only serve to increase fissile material assurance, it may actually reduce the cost and operational impact of the inventory program.

- **Physical inventory sampling plans are incomplete or do not include sufficient information.** Sampling plans often do not adequately specify the statistical assumptions and parameters applied to the inventory. In many cases, sample plans do not provide a detailed description of the inventory population and strata, the sample size, the sampling method, the confidence provided by the sample, the definition of a defective inventory item, the action to be taken if a defective inventory item is found in the sample, and methods to preserve the sample size and the randomness of the sample if an item is eliminated from the population for some reason after the sampling has begun.

- **Operations offices are approving inventory plans and sampling plans that are not complete or effective in achieving safeguards objectives**. Inventory plans and sampling plans are established by the facility and approved by the field office. Such plans are often approved without containing sufficient information. For example, sampling plans should define defects and the actions to take if a defect is found. Appropriate actions are generally defined for clear-cut cases, such as an item that has a measurement result significantly different from the accounting record or an item that is missing from its assigned location. However, sampling plans do not generally specify actions to be taken for more common occurrences, such as data entry errors or items misplaced within a material balance area.

Effective physical inventories are particularly important in light of the degradation of physical security at some sites and the continued weaknesses in inventory values. The positive closure provided by a physical inventory is the only means that DOE has of ensuring that a validated and comprehensive accountability system is in place. Physical inventories are key in ensuring that material has not been diverted. With the weaknesses noted above, physical inventories are not consistently effective in providing adequate assurance. Inventory programs need to be reexamined to determine whether more effective strategies can be developed to meet safeguards objectives more effectively and efficiently.

ISSUE A-2: Problems with Accounting for Holdup

The term "holdup" refers to nuclear materials that remain in process equipment and facilities (e.g., piping, tanks, ventilation ducts) after a process has been shut down. In many cases, such materials cannot be removed until the process equipment is dismantled. Measuring the amount of holdup involves significant uncertainties because of the assumptions that must be made (e.g., physical and chemical form of the material, dispersal and configuration of fissile material, and presence of obstacles that shield the material). Notwithstanding the uncertainties in the measurements, it is important to correctly account for holdup in order to: (1) ensure that holdup is included in the national system of safeguards, (2) accurately reflect the quantity of nuclear material at DOE sites, and (3) better

reflect actual inventory differences (not accounting for holdup can result in unnecessarily inflated inventory differences).

In the 1995 DOE Office of Oversight study on fissile inventory assurance, holdup was identified as one of the most significant issues. At that time, several sites had no valid measurements of the amount of holdup at their facilities and accounting practices were inconsistent and sometimes inadequate. Both the Oversight report and the Measurements Assessments Project (MAP) identified several needed improvements related to holdup, including the need to evaluate the accuracy of measurement methods.

Some sites have adequately addressed holdup concerns. Several sites, including Hanford and the Idaho Chemical Processing Plant, have longstanding programs to evaluate holdup; these sites have validated some of their measurements and have confidence in their accountability values. Several other facilities (such as Pantex) do not have significant holdup concerns because they do not perform processes that generate holdup.

In recent years, Los Alamos National Laboratory and Lawrence Livermore National Laboratory have devised techniques to address the potential for holdup in their process equipment, such as glove box processing limits and unit process monitoring, with associated resolution of losses. Further, some DOE sites, such as the Idaho National Engineering and Environmental Laboratory, have recently recovered holdup material as part of their ongoing decontamination and decommissioning (D&D) efforts. In cases where material recovery data is available, it has validated the measured values for several holdup measurements techniques.

Although progress has been made, concerns related to accounting for holdup are still evident at a few sites:

- The Rocky Flats Environmental Technology Site has performed some holdup measurements and has validated the measurements of holdup in ventilation ducts. They have measured the holdup in some of their glove boxes, however, they have not validated their measured values with an independent measurement. Rocky Flats has performed measurements in many areas where they expect holdup to be present. At one point in 1996, Rocky Flats had estimated plutonium holdup to be about 350 kilograms. However, this material was not booked when it was estimated. Rather, Rocky Flats booked fissile material only after the measurements were validated; about 120 kilograms have been booked to date and the current estimate of holdup is approximately 200 kilograms. Thus, there is about 80 kilograms of fissile material that has been identified but not measured or booked. In addition, Rocky Flats has not performed effective wall-to-wall reviews to ensure that holdup has been located, even though experience has shown that holdup is often found during such reviews. Rocky Flats has plans to perform wall-to-wall evaluations prior to downgrading safeguards for a building. However, these plans will not be accomplished for several years. Until the evaluations are performed, the magnitude of the holdup will not be known and any loss of the nuclear material will not be quantified or detected by the accounting system.

- The Portsmouth Gaseous Diffusion Plant has performed measurements to locate and quantify holdup in process equipment and piping, and is currently performing additional monitoring to assure that all areas containing highly enriched uranium holdup have been identified and measured. At two of three facilities with significant holdup, it was appropriately entered into the inventory records (i.e., the material was "booked"). However, in the high-assay cascade building, an estimated 625 kilograms of highly enriched uranium has not been properly "booked," and therefore the highly enriched uranium holdup in the cascade is not formally incorporated into the safeguards program. The failure to book holdup at the Portsmouth Gaseous Diffusion Plant requires particular attention because of the ongoing DOE plans to end all highly enriched uranium operations there. Currently, DOE retains responsibility for highly enriched uranium, while low-enriched uranium operations at that site fall under Nuclear Regulatory Commission (NRC) regulations, in accordance with the transfer of the site from DOE to the United States Enrichment Corporation (USEC). DOE plans to remove all highly enriched uranium

(except holdup) from Portsmouth by transferring it to another site or blending it down to a low enrichment; these efforts are expected to be complete by August 1999. The holdup material is likely to remain at the site for the foreseeable future because it is contained within welded piping and equipment that is not scheduled to be disassembled in the near future, and such an effort would take several years. Currently, the holdup is adequately protected; the material is dispersed throughout thousands of pieces of cascade process equipment and piping, and is contained within a material access area within a protected area, with an armed protective force paid for by DOE. Until all highly enriched uranium is eliminated from the site, it will be important to analyze the special nuclear material category and needed protection measures carefully to ensure that the remaining highly enriched uranium holdup is properly protected. It is also important to ensure that DOE and NRC coordinate effectively to ensure that jurisdictional issues are addressed in situations where highly enriched uranium holdup may be present in facilities leased to USEC (the NRC-USEC certificate has a limit on the enrichment that precludes the presence of significant quantities of highly enriched uranium at the leased equipment at the Portsmouth site). It is also important that the Oak Ridge Operations Office continue to evaluate the effectiveness of protection measures and ensure that holdup is properly accounted for, inventoried, and monitored. In addition, attention is needed to ensure that the efforts of the different prime contractors at the Portsmouth site (one supports DOE and the other runs most site operations under contract to USEC) are effectively coordinated in areas where there are interfaces (e.g., alarm systems, which may have sensors covering both DOE and non-DOE materials, and fissile material accountability records, which may need to be coordinated to resolve inventory differences). Further, it is also important that DOE, NRC, and USEC effectively coordinate to ensure that records concerning the amounts and locations of holdup are maintained, available, and appropriately used. Because of the potential for a nuclear criticality involving highly enriched uranium, such records will be important whenever equipment is moved or when material is removed from the equipment. (On prior removals of equipment, the measurement techniques were found to be acceptable for criticality and MC&A use.)

- The DOE East Tennessee Technology Park formerly the K-25 Plant, in Oak Ridge, Tennessee, has considerable holdup in their cascade that has been there since the site was shut down more than ten years ago (the high-assay operations were shut down more than 30 years ago). DOE determined that the level of protection, although much reduced from when the site was operating with highly enriched uranium, is appropriate, considering the difficulty in accessing the holdup in the cascade equipment. However, D&D efforts at East Tennessee Technology Park are under way and the cascade buildings are among the site D&D priorities. D&D of the cascade buildings will result in increased potential for access to holdup (e.g., by D&D workers when equipment is dismantled).

Practices for measuring and booking holdup once it has been identified need particular attention. Rocky Flats has estimated that 80 kilograms of plutonium are held up in the process and have not been measured or booked. The Portsmouth Gaseous Diffusion Plant has measured approximately 625 kilograms of special nuclear material that has not been booked. The failure to measure and book holdup can artificially inflate a site's cumulative inventory difference. In addition, not booking the holdup in the permanent inventory records increases the possibility that the locations of the holdup will be forgotten over time; such a

loss of information has implications for criticality safety as well as safeguards, because information on the quantity and location of holdup can be useful for planning work and establishing hazard controls. One reason that the Portsmouth site has not shown these materials in its inventory records is that the contractor believes that holdup in the cascade should not be booked, according to guidance issued by the Oak Ridge Operations Office. This practice may have been justifiable when the cascade was operating but is no longer appropriate since the high-assay end of the cascade has been shut down. In fact, the Oak Ridge guidance has simply not been updated to reflect the current operating status and is not consistent with DOE orders and generally accepted accounting principles.

A more general problem involves DOE policies and requirements related to holdup. Current DOE orders do not distinguish between fissile material assurance requirements for holdup and for other materials; that is, material in holdup is considered to be subject to the same requirements as other materials, including requirements for physical inventories and measurement programs. However, many (perhaps most) DOE sites do not include holdup in their physical inventories or in confirmation or verification measurements programs. Therefore, many sites may not fully comply with all aspects of requirements with respect to holdup. On the other hand, in some cases, it may be impractical or inefficient to apply the same inventory and measurement requirements to holdup. Thus, it may be appropriate to reevaluate DOE policies and develop order provisions and guidance that reflect the special issues associated with measuring, monitoring, and inventorying holdup.

ISSUE A-3: Inadequate Site-Specific Measurement Plans

As discussed in previous sections, DOE sites have characterized their unmeasured materials as part of the MAP effort. Materials were characterized as being either (1) not amenable to measurement, (2) difficult to measure, (3) having good measured values, or (4) being poorly measured.

The sites also submitted site-specific plans for measuring fissile materials that do not currently have defensible values. The plans are intended to address all major categories of unmeasured material identified by the MAP.

Although the MAP provided a good basis for developing the required plans, the quality of the plans varies substantially. Most DOE sites have not developed effective plans that can be realistically implemented, and only a few sites have progressed to the stage where they are actually performing measurements to reduce the unmeasured inventory. Some MAP plans are simply lists of materials with proposed dates for completing measurements.

The meeting results of the DOE Fissile Material Assurance Working Group (FMAWG) indicate that most sites are reporting that they are meeting milestones established in their measurements plan. Such progress reports, while technically correct, may be painting a somewhat rosy picture of the actual progress. In practice, some sites have not missed milestones that allow them several years to complete measurements; however, those sites have made little or no progress in performing the measurements and have not yet demonstrated that they can gain the necessary support and resources to implement their plans. In some cases, the only demonstrable progress has been the selection or procurement of equipment.

Many plans do not demonstrate that the site contractor MC&A organization has obtained the needed funding and resources to perform measurements, or that the contractor senior managers are going to support the planned efforts. Few sites have formally coordinated the planned activities with their DOE operations office or program office.

In addition, few sites have performed detailed planning or evaluated and addressed the obstacles (e.g., radiation exposure, safe handling of materials, standards, packaging, final form, impact on operations, and funding mechanisms) that may be encountered when performing measurements. A few sites have obtained equipment (or are in the process of obtaining equipment) but may not be able to use that equipment to perform measurements in a timely manner because they have not allowed enough time for installation and operation of the new equipment. For example, sites have obtained funds for new measurement equipment but have not budgeted for the construction of the facility needed to operate the equipment.

A more common problem is that DOE sites do not have measurements standards (i.e., items that are similar in shape and composition to the materials to be measured and that have known amounts of fissile material) for some types of fissile materials. Without such standards, NDA instrumentation cannot be calibrated and validated, and sites cannot obtain a defensible measurement and inventory value. In addition, NDA instrumentation often needs to be designed to accommodate the wide varieties of scrap and waste (e.g., the size of items to be measured can vary from a small item to a 55-gallon drum). The design and standards development process can be time-consuming and requires significant resources. As a result, some forms of scrap are so unique that it may not be practical to fabricate standards for them.

DOE has begun to evaluate the need for additional standards to support the measurement of unmeasured or poorly measured nuclear material. Specifically, the New Brunswick Laboratory has been tasked to survey the complex to identify what types of NDA standards are needed. If needed standards are identified and the standards are defined and fabricated, DOE will have the tools to address a significant portion of the problem. However, the goal of the New Brunswick Laboratory survey is to identify standards that are needed across the complex; it is not clear that the effort will address the wide range of materials at DOE sites and the site-specific problems that are hindering site efforts to perform measurements. Additional attention is needed to coordinate the New Brunswick Laboratory effort with the needs of individual sites to ensure that all problems are being addressed. Such coordination would be an appropriate activity for the FMAWG.

Some fissile materials cannot be adequately measured until they are processed into a measurable form. For example, the Y-12 Plant identified 1,500 kilograms of uranium (this amount has since been reduced through additional analysis) that could not be measured, either because they did not have equipment or because the material could not be processed during the safety-related shutdown. Much of the material with unmeasured or poorly measured values resulted from the consolidation of DOE scrap. For more than 20 years, DOE has transferred such materials to Y-12 under the Central Scrap Management Organization (CSMO) program. This program provided only for the consolidation of the materials but did not address the timely verification of the quantities received at the facility. Similar problems are evident at other sites. Recognizing that certain materials cannot be adequately measured until they are processed, DOE needs to ensure that fissile material assurance needs are given appropriate priority as processing capability becomes available.

To ensure that the measurement plans are implemented, DOE needs to take a more active role in developing the plans and monitoring progress. From the operations office perspective, increased involvement is needed to ensure that the plans identify priorities and realistic milestones, and that the necessary resources are identified and allocated. Although some major activities may require incremental funding, much of the needed measurements can be performed with in-house resources if contractor senior management ensures that those efforts are a site priority. Operations offices can use various mechanisms to ensure that establishment of and adherence to measurements plans are a site priority, including contractual performance measures and appropriate rewards and sanctions.

From the DOE Headquarters perspective, the operations office and program offices need to be held accountable for establishing realistic plans and establishing and meeting meaningful milestones. The Security Management Council that was established to provide direction and monitor progress in addressing safeguards and security issues could provide a forum for ensuring progress. For example, the Security Management Council could require each program office to provide regular briefings on the status of measurement plans and progress toward achieving established milestones. In addition, the Associate Deputy Secretary for Field Management (FM) could take a more active role in establishing plans and monitoring and reporting progress.

The Y-12 Plant is one of the DOE sites that has developed a detailed plan identifying both measurement methods and resources. The Oak Ridge Operations Office and contractor MC&A organizations have coordinated the plans with Y-12 production/operations personnel and obtained the support and concurrence of the contractor and Oak Ridge Operations Office senior managers. The Y-12 measurement plan was submitted to the FMAWG for review and revised to incorporate FMAWG comments, including the suggestion to shorten the time frame needed to complete the effort from ten years to five years. The site identified the funding ($6.4 million over five years) necessary to complete the project.

Although the contractor and the Oak Ridge

Operations Office have developed a feasible plan and identified a viable funding mechanism for some of the costs, the plan is not yet being implemented while DOE Headquarters Office of Defense Programs (DP) is reviewing the plan While a DP review is appropriate, it may be that attention is needed to ensure that the DP review is completed and any necessary modifications are made in a timely manner. The DP review has been in progress for more than six months and has involved several DP organizational elements. To expedite progress, DP needs to ensure that its review is streamlined and coordinated among its various organizational elements, and that a decision on approval is reached in a timely manner. The basic elements of the Y-12 plan have already been briefed to the Deputy Secretary; senior DP managers present at that briefing indicated that there were no issues that would prevent the plan from being implemented.

Timely action on the Y-12 plan is particularly important for several reasons. The Y-12 Plant has hundreds of kilograms of unmeasured or poorly measured fissile materials. Some of this material was generated at Y-12, but much of it is uranium scrap generated at other sites. Some of this material has not been measured by Y-12, and thus DOE is relying on the shipper's values. In addition, Y-12's ability to accurately account for fissile materials has been hindered by the shutdown of many operations for several years to address safety issues. As Y-12 resumes operations, it will be necessary to be able to ensure that materials are being measured and to address problems with unmeasured materials.

ISSUE A-4: Problems in Ensuring that Policy Is Current and Issuing Revisions to DOE Orders

Several of the issues identified in this section are partially attributable to weaknesses in DOE policies and order requirements, or failure to adhere to those requirements. The current version of the DOE order governing MC&A is DOE Order 5633.3B, Control and Accountability of Nuclear Materials, which was issued in 1994. There is a general consensus that the current order needs improvement for a variety of reasons. In some cases, the provisions are unnecessarily prescriptive, resulting in situations where resources are devoted to meeting rigid requirements that do not necessarily improve fissile material assurance. In other cases, order provisions are ambiguous or unclear, resulting in wide variations in interpretation and implementation from site to site.

Several factors prompted NN to initiate an effort to revise the DOE MC&A order in 1996. The 1995 Oversight report identified some needed changes to DOE policy. Subsequently, the FMAWG made recommendations for improvement in the order that reflect a consensus of field personnel. In addition, DOE was in the midst of an effort to improve DOE orders by making them less prescriptive, allowing the sites more flexibility in how to achieve requirements.

With the assistance of the FMAWG, a new order was drafted. At that time, there were suggestions to perform a substantial rewrite of the DOE order and to consider a different approach to writing requirements (i.e., establishing acceptance criteria in a manner similar to the approach used by NRC). However, at that time the policy makers determined that they needed to move quickly to complete the revised order in a short time frame. Consequently, they decided to fix selected items and shorten the order by moving some of the details into guidance documents.

Although a draft was prepared and there was a perceived need for an expedient revision, the effort to revise the order lost momentum, and the draft order has been in limbo for more than a year. During this time, there has been some discussion, and some FMAWG recommendations have been incorporated into various versions of a draft order. However, many of the unresolved policy issues have not been addressed in the drafts, and efforts to resolve important issues are moving slowly. More than a year after it was considered a priority effort, the revised draft order has not been sent out for formal comment and concurrence.

The reasons for the virtual cessation of efforts to issue the revised order are not clearly specified or documented. However, the underlying factor appears to be that the MC&A community is unable to agree on certain provisions of the revised order. NN, the organization with responsibility for revising and reissuing the order, has made some efforts to resolve issues but has not made formal dissemination of the revised draft order for review and comment a priority.

The Office of Oversight recognizes that there are legitimate differences among professionals that are difficult to reconcile, and that it may be impossible to gain unanimous agreement on controversial issues. However, the current stalemate clearly serves no purpose, and the lack of action is leading to problems. For example, some changes that are generally viewed favorably have been delayed by prolonged discussion of the divisive issues. In addition, sites are continuing to implement certain prescriptive provisions for which less expensive alternatives may be available if the requirements were more flexible.

A related concern is the growing trend to tolerate non-compliance with the DOE order provisions at DOE sites and DOE operations offices. For example, while the order requires that the material being transferred from one site to another is measured by both the shipper and the receiver, many sites negotiate shipper/receiver agreements through their operations offices that do not require both measurements. In another example, most sites do not include irradiated fuels in their physical inventory programs while the order does not exclude them from the physical inventory and measurement requirements. As discussed below, this trend has its roots in disagreements over policy, the inability of MC&A organizations to obtain management support, and the increased reliance on physical protection.

In a some instances, DOE operations offices and contractors disagree with the order requirements or believe that they should not apply to their sites. Accordingly, several DOE sites have chosen not to implement certain provisions, but have not requested a formal deviation or exception from the approving authority (the operations office or DOE Headquarters) to obtain approval of their non-compliance. Sites have indicated that, in some cases, they do not send in deviation requests to Headquarters because they are likely to be disapproved by personnel at Headquarters who have different views on the order requirements.

In other instances, the DOE contractor MC&A staff may believe that an order requirement is applicable and appropriate but cannot implement it because they lack the needed support or resources (equipment, technicians, funding). Although recognizing the weakness in the fissile material assurance program, the MC&A staff at some sites have been unable to effectively implement requirements but have not provided a justification for a deviation or exception.

As noted, DOE has traditionally relied on physical protection to reduce risks to acceptable levels, to the extent that DOE and contractor managers at some sites accept weaknesses in fissile material assurance because the primary protection objective is being met (i.e., providing adequate protection against theft of fissile material); that is, DOE and contractor managers are rationalizing their non-compliance. This trend is evident in several sites' failures to perform physical inventories, and in the increasing tendency to interpret DOE order provisions freely or to implement programs that do not accomplish the intended safeguards objective. For example, the order provides the option of using a statistical sampling approach to performing physical inventories and measurements. Properly implemented, a statistical sampling approach can provide adequate assurance that materials are present and accounted for. However, some sites, with the explicit or tacit approval of the operations office, are implementing this approach in a way that provides little assurance (e.g., the number of items selected in the sample may be too small).

A more general problem is that many DOE order requirements, which were often originally written many years ago, have not kept pace with changing conditions. For example, until recently, it was relatively rare for a DOE site to shut down operations for an extended period because of safety concerns, and thus it was not important to establish acceptable compensatory measure to deal with such shutdowns. Similarly, accounting for fissile materials in irradiated fuel has recently become a topic of debate within DOE. Previously, material measurements and inventory for irradiated fuel were seldom considered important because the fuel was considered so highly radioactive that no one would be able to steal or divert it; that is, it was "self-protecting." Further, the irradiated fuel was generally processed as soon as its radioactivity decayed enough to allow the valuable fissile materials to be recovered. For various reasons (e.g., reduced need for plutonium and the shutdown of many processing facilities), DOE has not processed irradiated fuel for a number of years. As a result, the current inventory of irradiated fuel has decayed to the point where it is no longer clearly self-protecting (although it is still highly radioactive). From the policy perspective, irradiated fuel presents a new situation because it is no longer self-protecting according to the established criteria, yet there are no feasible methods for measuring its contents. As conditions and driving forces have changed over the years (greater emphasis on

safety, more external scrutiny, increased ability to tolerate extended shutdowns because of reduced need for facilities for weapons production), DOE policies and orders have not been modified to reflect the changing needs.

In light of the changing conditions and new priorities, a significant overhaul of the order is needed. While certain provisions have been modified to address specific problems, there has not been a comprehensive and systematic analysis of the requirements for a considerable period. There are a number of controversial and contentious issues being debated, such as policies related to irradiated fuels and termination of safeguards. In addition, there are other fundamental questions that need to be evaluated. For example, the entire approach to providing adequate assurance for fissile materials in long-term storage could be reexamined. Current order requirements do not distinguish between materials in long-term storage and other materials (although guidance issued by NN allows sites to reduce the frequency of physical inventories for materials in long-term storage if certain conditions are met). As DOE places more materials in long-term storage, it may be prudent to establish policies that ensure effective safeguards while promoting innovative approaches to reduce the costs and impacts (e.g., radiation exposure) of performing fissile material assurance functions.

DOE also needs to reexamine the entire "one size fits all" approach to fissile material assurance. There are certain types of materials, such as weapons components, spent fuel, mixed oxide fuel elements (which could be fabricated to implement the DOE's Record of Decision on long-term plutonium disposition), and holdup, that may merit special requirements to achieve an optimal balance of fissile material assurance and cost effectiveness. The DOE order, including the roles and responsibilities of various organizations, also need to be reexamined to ensure that sufficient controls are in place and that the MC&A organization has sufficient involvement in actions that could affect safeguards.

It is also important to consider reevaluating the DOE orders in light of the IAEA and NRC requirements to determine where they should be changed for consistency, since much of DOE's materials will eventually be offered for inspection by the IAEA and possibly placed under NRC regulation. Both DOE and non-DOE (IAEA, bilateral treaties, NRC) fissile material assurance requirements have a number of common objectives, such as physical protection against theft and timely detection of loss or diversion of fissile materials. However, there are differences in the specific requirements in various areas, such as the requirements for documentation. Some of the differences result from the fact that the IAEA must examine the possibility that the whole country is systematically diverting materials, whereas DOE policies focus on providing assurance that a terrorist group or an insider has not diverted materials. In the interest of efficiency and consistency, it may be prudent to examine DOE policies to ensure that they consider this eventual transition. Where feasible, it may be most effective to make DOE policies more consistent in approach and detail with those of IAEA, particularly for those materials that are not expected to be needed for defense purposes.

As part of an overall effort to reconsider the order, one option is to adopt a different approach to establishing site-specific requirements. More specifically, DOE should consider using an approach that relies on acceptance criteria (measures of adequacy used to assess performance of MC&A programs) rather than prescriptive requirements. This approach is analogous to the approaches used by NRC has proven effective in regulating diverse types of fissile material assurance programs. The primary advantage of the acceptance criteria model is that it focuses on defining objectives rather than on the means for implementing them. No document can cover all possible methodologies that a facility might use to achieve the desired objectives. The acceptance criteria approach, with associated performance measures, provides a common basis for establishing adequate performance while providing individual sites with the flexibility to design and operate their fissile material assurance programs in the most effective and efficient manner. The acceptance criteria model has other possible advantages in that it would bring DOE into closer alignment with NRC requirements, minimize the need for periodic order changes, simplify and streamline the process of revising orders, and make it easier for operations offices to review and evaluate site MC&A Plans. However, adopting this model would require substantial effort to develop the acceptance criteria and would require sites to develop MC&A Plans that are more detailed than many current MC&A Plans; the new plans would have to demonstrate how the performance objectives are met. Such an approach will require gradual acceptance and

implementation, but has potential long-term benefits in efficiency and facilitating the transition to NRC regulation.

The acceptance criteria model has considerable support within the MC&A community. However, no concrete action has been taken to evaluate its potential costs and benefits. Regardless of whether the acceptance criteria model is adopted, an overhaul of DOE orders is needed for the reasons described previously.

Although an overhaul is needed, the ongoing efforts to issue a revised order should not be further delayed by extended reconsideration. The changes recommended by the FMAWG are important and should be resolved as soon as possible so that the revised order can be reviewed, modified as needed, and issued. Attention is also needed to streamline and improve the order revision process, with a particular focus on determining how to keep stalemates over specific issues from halting the process. For example, it is possible to issue a revised and improved order even if certain provisions are not fully resolved; viable mechanisms are in place to issue page changes to incorporate a final resolution. Such approaches should be considered in order to break the current stalemate on the revision to the DOE order.

In general, the DOE MC&A community could benefit from improvements in the issue resolution process, as demonstrated by the delay in revising the MC&A order because of the inability to resolve issues. Many policy issues are complicated and contentious, and legitimate differences of opinion are both reasonable and expected. However, the current gridlock on certain issues is affecting the order revision, and there is little likelihood that a consensus position will evolve on important issues, such as appropriate safeguards for spent fuel.

To address this situation, DOE needs to establish and implement an effective issue resolution process to ensure that issues are debated only for a reasonable period and are not left in limbo when agreement cannot be reached at the working level (e.g., mid-levels of NN management and safeguards personnel in the field, typically at the Branch Chief level). When it becomes evident that the factions have become polarized and are not likely to come to a consensus in a timely manner, dispute resolution processes will be needed to bring the issues to higher levels of management, such as FM, NN-1, operations office managers, and program office personnel.

A key aspect of establishing an issue resolution process is ensuring that there is an individual or group with the final authority to make decisions when a consensus cannot be achieved. For example, a group such as the DOE Security Management Council could provide a forum for hearing both sides of an issue and serving as the final arbiter. The central authority must consider all aspects of the issues, including security benefits and cost implications, in reaching decisions, and must ensure that the resolution leads to effective fissile material assurance and effective policies.

The problems encountered with revising DOE orders and resolving issues are not unique to the MC&A community or to safeguards and security. Similar problems with direction from multiple sources, slow decision processes, ineffective dispute resolution practices, and lack of a clear decision-making authority, are also evident in many aspects of DOE operations, such as waste management and emergency management.

ISSUE A-5: Implementation of Termination of Safeguards Policy

"Termination of safeguards" means that the materials have been determined to be discardable (i.e., of no further economic value and not weapons-usable because of very low concentrations of fissile materials or other factors). Once safeguards are terminated, the MC&A organization no longer accounts for the materials for safeguards purposes. The materials are moved to a storage or disposal area where there is little security, or the materials remain in a facility and the protection measures for that facility are discontinued.

DOE orders specify that a site can terminate safeguards for fissile materials if certain conditions are met. The decision to terminate safeguards can be approved by the operations office for some materials (Attractiveness Level E). For more attractive (i.e., in a form not conducive to theft or diversion) materials (Attractiveness Level D), the DOE Headquarters program office must approve termination of safeguards.

Most DOE sites have informal approaches for determining whether safeguards can be terminated, and interpretation of the requirements varies widely. Some sites do not adequately involve the MC&A organization in the early stages of plans to terminate safeguards or change protection measures. In addition, there is no mechanism in place to identify or track termination of safeguards transactions. In

many cases, sites do not maintain records of the types of materials or the total amount of material for which safeguards have been terminated.

Without adequate controls for termination of safeguards, materials could be inappropriately removed from a protected facility, or protection measures could be removed from a facility that contains significant quantities of fissile materials. These possibilities are exacerbated by the fact that safeguards are often terminated for materials that were not measured reliably, and thus sites cannot be positive that the materials are in fact appropriate for discarding. In addition, many sites have contractual incentives (e.g., performance bonuses and/or penalties) to empty out specified facilities and terminate safeguards so that they can meet D&D goals and/or reduce safeguards and security costs. On at least one occasion, significant pressure to remove materials from a facility contributed to the site contractor's decision to terminate safeguards before analyzing the materials and the potential safeguards impact; in this event, the decision was later reversed and the materials were brought back into a protected facility. In addition, there has been at least one occasion where, as part of a D&D effort, a site initiated termination of safeguards on a facility after it had removed all known fissile material items, even though the facility was known to contain holdup that was not well characterized. When this situation was brought to the site's attention, they decided not to terminate safeguards at that facility. Additionally, holdup material not adequately characterized can pose significant safety and health hazards during dismantling operations.

Termination of safeguards requires better controls because there is normally no room for error. When safeguards are removed, materials are out of accountability, and protection measures are removed. Under these conditions, it is difficult to regain control of the materials, particularly if the records of what items were terminated are incomplete or missing—as is often the case. Consequently, termination of safeguards opens a number of viable paths for theft or diversion of material. Such a diversion might not be detected for a considerable time period, if ever, if there are inadequate controls on efforts to terminate safeguards. There is an ongoing NN initiative to expand the national NMMSS database to include transactions-based waste tracking for the purpose of addressing this problem.

Another reason to improve policies for termination of safeguards is that it may be necessary to characterize the storage or disposal locations in the future. Many of the problems and costs associated with the massive ongoing cleanup of DOE sites is that there are poor records of what hazardous materials are in each facility or storage area. Keeping better records now may someday help avoid the same mistakes that caused the extensive problems now being experienced in cleanup.

ISSUE A-6: Policy for Irradiated Materials

Policies involving irradiated materials are a subject of current debate. There is no consensus on what additional measures are needed to protect irradiated nuclear materials from theft, diversion, and sabotage.

DOE orders have some special provisions for material that is "self-protecting," which is defined as material having radiation levels greater than 100 rem per hour at a distance of one meter from any surface without intervening shielding material. Irradiated fuels (also referred to as spent fuel) from various types of nuclear reactors constitute the vast majority of self-protecting materials. At the specified radiation level, self-protecting materials are very difficult to handle, and anyone accessing them directly would receive a substantial radiation exposure, which could be incapacitating within a few hours. Thus, DOE requirements for physical protection of self-protecting materials are substantially less than for other fissile materials.

Irradiated materials must be included on inventory records, and DOE policy does not exclude irradiated materials from physical inventory or measurement requirements. However, there is no technologically feasible method of accurately measuring the actual amount of fissile material in irradiated fuels, and DOE sites have relied on calculations (fuel burnup) to determine this amount. Such methods were generally accepted because the spent fuel was from U.S. reactors with known characteristics, the radiation levels were so high as to deter access, and there were no feasible alternatives.

For most of DOE's history, irradiated fuels were processed before they dropped below the level of self-protection. Since DOE has stopped

processing most irradiated fuel, a new problem is emerging. Thousands of kilograms of irradiated materials have been in storage for an extended period without being processed, and they have dropped, or will drop, below the level where they are considered self-protecting. For this substantial quantity of material, which clearly requires some degree of protection and control, there is no policy governing its disposition. This problem is compounded by the fact that a steady and increasing influx of spent nuclear fuel is returning to the U.S. from various foreign countries. Much of the domestic and foreign irradiated fuels contain plutonium and/or highly enriched uranium and could be processed into weapons-usable material by a malevolent country or group that had the necessary technology and resources.

Only a few sites have significant amounts of highly irradiated fuel (Hanford, Argonne National Laboratory-West, Savannah River Site, and Idaho National Engineering and Environmental Laboratory). Most of the highly irradiated materials are at sites that are undergoing D&D and are increasingly moving materials to IAEA safeguards.

The potential risks associated with highly irradiated materials include:

- **Diversion prior to receipt.** With few exceptions, it is not technically feasible to measure irradiated materials upon receipt to assure that the material and quantity received is as stated by the shipper. Thus, DOE cannot be positive that the shipments actually contain the amount of material indicated by the shipper, which could be a foreign country. It would clearly be difficult to divert fissile materials from spent fuel or to substitute similar non-fissile irradiated materials for the spent fuel, and thus an adversary would have difficulty in a diverting such material before the U.S. received it. However, such an event might not be detected for a long time if it were to occur.

- **Inability to detect theft and diversion.** In most cases, it is not technically feasible to perform accountability measurements or verification measurements on irradiated materials, and most sites perform few if any confirmation measurements. Therefore, there is no reliable mechanism to verify that receipted materials are still present at the site.

  The risk of theft or diversion has generally been thought to be low because of the materials' high radiation levels; however, as noted, those levels drop over time.

- **Sabotage.** Because the risk of theft has generally been viewed as low, the physical protection requirements are minimal for self-protecting materials. However, because the physical protection measures are minimal, sabotage of irradiated materials could result in significant consequences (e.g., radiation exposure and contamination).

Some of the specific problems associated with irradiated fuel include:

- Some techniques have been developed to perform confirmation measurements of some attributes of irradiated materials. However, the technology to perform accurate measurements does not exist for most types of irradiated materials.

- DOE is facing issues not often faced before, and DOE orders and guidance do not specifically consider the current situation:

  - As the level of radioactivity decreases with time, irradiated materials are no longer clearly self-protecting, although they are still highly radioactive; thus the bases for historical practices need reevaluation.

  - DOE has not often faced issues regarding acceptance of spent fuel from other countries; without measurements on receipt, DOE has no way to verify the actual amount that it has received except to rely on the shipper for accurate information.

- Burnup calculations can provide very accurate values for fuel elements—if the fuel elements remain intact. However, the physical condition of some fuel elements is degrading because of long-term underwater storage and high radiation levels. (For example, pieces of the

fuel elements are breaking off and falling to the bottom of spent fuel pools.) DOE policy and guidance does not specifically address mechanisms for accounting for fissile materials in degraded fuel elements or in loose pieces, and DOE sites have not developed methods for accounting for such materials.

- Safety and health considerations make it difficult to perform such operations as confirmation measurements on highly irradiated materials.

- In a few cases, highly irradiated materials are stored in the same area as unirradiated or slightly irradiated materials. In such cases, the presence of a high radiation field is used to justify reducing or eliminating physical inventories and measurements on the unirradiated or slightly irradiated materials, even though they would be required if the materials were not collocated with the highly irradiated materials.

- Issues associated with placing irradiated materials under IAEA safeguards have not been addressed.

The FMAWG established a subgroup as part of the MAP to consider the risks of diversion, theft, and sabotage involving materials that are highly irradiated but no longer self-protecting. The subgroup was tasked to prepare a position paper entitled "Program Direction for the Safeguarding of Spent Nuclear Fuel" but could not reach a consensus. One faction indicated that it would not be prudent to establish additional requirements (or even to meet existing requirements) for Attractiveness Level D material (which the irradiated fuel would be, if it were no longer self-protecting according to the established criteria). This faction cited the difficulty, expense, potential hazards, and lack of technology to perform measurements or physical inventories of irradiated fuels, and indicated that enhanced physical protection or implementing physicals inventories and measurements would not be prudent considering the potential risks, which they viewed as low, and the costs, which could be significant.

Another faction of the subgroup indicated that measurements of irradiated fuel are important and must be supported. The NN co-chair of the FMAWG supported the need for measurements of irradiated materials in the briefings to senior managers.

Most, but not all, sites supported the concept of performing confirmation measurements to provide assurance that irradiated materials are present. There were different perceptions as to whether it is technically feasible to perform measurements that are sufficiently accurate for accountability or verification measurements.

A consensus on the degree of risks will be difficult to achieve because the two factions have different perceptions of the risks associated with irradiated materials and the benefits of additional safeguards measures. Although a comprehensive policy that has the support of both the field and NN is not imminent, some items could be addressed:

- Risks associated with collocated materials should be analyzed and appropriate policies and guidance developed to ensure that those risks are acceptable.

- Spent fuel that is physically deteriorating should be addressed.

- DOE practices should be analyzed to determine their compatibility with IAEA and NRC requirements, and whether any policies and guidance need to be developed to provide comparable levels of protection or to facilitate the transition to IAEA safeguards or NRC regulation.

- An assessment of the available technology could be performed to determine what types of measurements and physical inventory methods are feasible, and whether a set of feasible measures (e.g., periodic confirmatory measurements) that provide adequate protection can be established.

ISSUE A-7: Overreliance on Physical Protection Measures

The Atomic Energy Act of 1946 (as amended in 1954) requires DOE to perform two complementary and related functions: protecting fissile materials and accounting for fissile materials. Although complementary, these two functions have distinct purposes, and both are necessary to ensure that fissile materials do not fall into the wrong hands. The protection function, which corresponds to the "security" portion of a safeguards and security program, consists of the measures that **prevent** unauthorized access to or removal of fissile materials. Protection measures at DOE sites include physical barriers, intrusion detection systems, access controls to limit entry, material controls (e.g., tamper-indicating devices, daily administrative checks, two-person rule), personnel security programs, administrative controls, and protective forces. Conversely, fissile material assurance, which corresponds to the materials control and accountability element of the "safeguards" portion of a safeguards and security program, **provides assurance** that the materials are still there and thus provides the verification that the protection measures have been effective.

Historically, most of the attention has been on the adequacy of protection measures, which are more visible and involve the vast majority of safeguards and security expenditures. Protective forces alone consume over 80 percent of DOE safeguards and security expenditures, and much of the rest is devoted to installation and maintenance of physical security intrusion detection and access control systems. Fissile material assurance has received less attention over the 50 years that DOE sites have produced and processed fissile materials. However, protection measures alone are not sufficient. For example, without effective fissile material assurance measures, it would not be possible to determine whether materials were diverted during a time when protection measures were degraded, such as during an emergency evacuation.

Over the years, DOE has tended to rely on physical protection programs and thus has tolerated weaknesses in fissile material assurance programs. For example, as new measurement technology became available, some DOE sites obtained equipment to perform measurements and others did not. Even when equipment was obtained, in some instances DOE and the contractors made the decision not to devote resources to measuring old, poorly measured materials.

DOE has often justified this reliance on physical protection by evaluating the risks of theft and diversion. According to a risk-based approach, if the risks of theft and diversion are low, the impact of weak fissile material assurance measures is minimal, and thus it may not be worthwhile to devote resources to performing measurements or other fissile material assurance activities. For example, there have been many situations where DOE sites have determined that it was acceptable to put fissile materials in secure storage (e.g., a sealed container in a vault in a material access area) even if the amount of fissile material in the container had not been accurately determined. If all the protection measures are reliable and DOE sites can verify that the container is still there and properly sealed, it can reasonably be assumed that all the material is still there, even if the precise amount is not known. This approach provides reasonable assurance that material has not been stolen or diverted; however, it does not provide assurance that DOE knows precisely how much is in that container, and it cannot be independently verified that the same amount of material has remained the same.

The reliance on a physical protection and a risk-based approach is perfectly valid, at least up to a point. However, physical protection alone is not sufficient to meet DOE's statutory responsibility to accurately account for fissile materials. But overreliance on protection at the expense of assurance has significant pitfalls. For example, over periods of many years, even sites that traditionally have good security programs are likely to experience periods where security is degraded, or may experience situations where an emergency inventory is needed. In addition, fissile materials are sometimes moved from a highly secure location to a less secure location—for example, as part of a consolidation effort. Further, fissile materials may be designated for transfer to IAEA safeguards or an NRC-regulated site. In any such instances, the weaknesses in fissile material assurance will become apparent. It is not uncommon for sites with poor fissile material assurance to also have poor record keeping, so that when such problems eventually come to light, they are difficult to resolve.

In the past ten years, much of DOE's fissile material inventory has been in storage because many DOE facilities and operations have been shut

down or put on standby. In this situation, it was relatively easy to justify the reliance on physical protection measures to mitigate weaknesses in fissile material assurance; for example, it was reasonable to assume that materials locked in secure storage and rarely handled were unlikely to be diverted. In such situations, the need for a rigorous and comprehensive inventory/measurement program was questioned, and DOE and contractor managers often justified reducing inventory or measurement practices. Correspondingly, resources allocated to fissile material assurance functions were often reduced, and fissile material assurance had fallen off the screen of management attention.

This trend, however, will not be as viable in the future because of such activities as resumption of processing, increased handling and transfers needed to consolidate materials, good measurements for materials in long-term storage, and placing materials under IAEA safeguards. To meet anticipated fissile material assurance needs, DOE sites will have to reexamine their current practices in light of emerging priorities and allocate resources in a more balanced fashion.

ISSUE A-8: Inconsistent Program Direction and Support from the FMAWG and Line Management

Although it is technologically possible to measure most fissile materials with currently available measurement technology, measurements can be costly and can introduce the potential for hazardous conditions. Decisions to conduct measurements need to be based on analysis of improved safeguards effectiveness, international implications, impact on worker health and safety, and the cost and availability of equipment. As indicated in the 1995 Office of Oversight report, enhanced policy, definitive guidance, better coordination, and increased management support are needed to ensure that decisions about measurements are cost effective and reflect DOE priorities. Oversight also indicated that an MC&A steering group, consisting of representatives from contractors, operations offices, and program offices, should be established to conduct a systematic and coordinated effort to enhance fissile inventory assurance. This recommendation was endorsed by the Inspector General in 1996.

The resulting group, the FMAWG, consists of personnel from NN, DOE program offices, DOE operations offices, and DOE contractors. The FMAWG has one co-chair from Headquarters (currently NN) and one from the field (currently a DOE field element). The FMAWG formed three subcommittees to address 1) policy, 2) operations, and 3) technical capabilities.

The responsibilities of the FMAWG include:

- Support program offices, operations office, and facilities in establishing and addressing coordinated and consistent Departmental goals and priorities.
- Promote the inclusion of MC&A issues early in planning processes.
- Champion high-quality MC&A practices to meet national and international standards as DOE facilities resume operations involving conversion of fissile material to more desirable forms for ultimate disposition.
- Monitor and prioritize DOE's efforts to measure material, and assure that materials are shown in the inventory records.
- Review and develop policies needed to address bilateral and international measurements and inventory issues.
- Coordinate and guide studies on the effectiveness and cost/benefit of safeguards needs as facility missions evolve.
- Coordinate and guide efforts to standardize methods, technology, and containers.
- Recommend studies of facility needs and equipment usage and promote sharing of resources.

Since its formation in 1996, the FMAWG has been a good forum for sites to discuss problems related to policy, implementation of policy, technical issues, management, and budget with DOE Headquarters. The FMAWG has also had some success in raising the visibility of fissile material assurance within DOE Headquarters, and has provided briefings to senior DOE managers.

The FMAWG's most significant accomplishment has been the completion of the MAP. The site submittals for the MAP still contain a number of invalid assumptions that detract from the comprehensiveness of the effort; for example, a few sites did not identify all unmeasured materials or indicated that certain materials had defensible measured values when in fact the measurements are not reproducible or the records are inadequate. However, the MAP was generally successful in identifying and characterizing fissile materials that do not have defensible values. In this respect, the MAP has been instrumental in helping the DOE complex develop a much better understanding of the extent of the fissile material assurance problem.

The FMAWG played an important role in ensuring that the sites developed reasonably good assessments of their unmeasured materials as part of the MAP effort. The initial directions provided to the sites were unclear, and the initial submittals by the sites were generally incomplete and not sufficient to meet the project goals. However, the FMAWG performed several reviews and communicated with the sites so that the final products generally provided a good characterization of fissile materials.

One of the reasons that the MAP was successful is that it had support from senior DOE management. The FMAWG had established a measurements assessment subgroup soon after the FMAWG was formed. However, little progress was made until the effort gained the attention and support of senior management. In July 1996, the MAP effort was chartered by the Secretary of Energy and was performed at the direction of EM-1. At that point, sites began to cooperate on analyses of their material holdings. This illustrates the point that the FMAWG, and MC&A programs in general, need senior management support to make a positive impact on fissile material assurance programs.

The FMAWG has also been active in recommending policy improvements and identifying the technical issues that need attention. For example, a set of recommendations for improving fissile inventory assurance was disseminated in a February 1997 memorandum. The field reviewed the recommendations for safety, cost and operations impact, and a final list of recommendations was presented to the National Security Cluster in September 1997. Most of the issues raised by the Office of Oversight in 1995 have been discussed by the FMAWG and were captured in the FMAWG recommendations.

Overall, although the FMAWG has had a positive impact, it is only partially achieving its objectives. The most significant problems are that: (1) it is not addressing all of its responsibilities, and (2) its efforts have not led to timely resolution of issues.

Responsibilities Not Fully Addressed

The FMAWG has an extensive set of responsibilities, some of which are being performed; however, others are receiving low priority or are not being addressed at all. For example, the FMAWG has not developed guidance for prioritizing issues or performing cost/benefit analysis and has not focused on policies associated with inventory values and measurements as they apply to offering materials up for inspection by the IAEA. In addition, there are technical issues that need to be addressed as DOE facilities resume operations to convert fissile material to more desirable forms for ultimate disposition.

One of the key roles of the FMAWG envisioned in the 1995 report was to be an advocate for fissile material assurance issues at DOE Headquarters. As demonstrated by several sites' failure to conduct physical inventories, the FMAWG has had only limited success in raising the visibility of fissile material assurance and ensuring that MC&A has appropriate levels of support when its objectives compete with operational or safety objectives. Without increased support, MC&A organizations are likely to continue to be a relatively low priority with site management.

In addition, increased FMAWG attention could help avoid potential problems in some areas. For example, the 1995 Oversight report highlighted a need for a balanced and integrated approach to fissile material assurance issues that considers ES&H, radiation exposure, criticality safety, D&D planning, international inspection activities, and material disposition. On a number of occasions, FMAWG could have provided more value to DOE by taking a more active role in promoting such an approach. For example, DOE made progress in developing a standardized container (the STD-

3013), but this container has not been validated, verified, or accepted by the IAEA. By helping to coordinate such activities with the IAEA, the FMAWG could help DOE avoid having to repackage materials (which involves additional costs, radiation exposure, and time), which could occur if the DOE container does not meet IAEA requirements.

Similarly, the FMAWG could be valuable in helping to guide efforts to improve information management, at both the site and the national level. At the site level, DOE has experienced a number of problems in attempting to develop a computer program to facilitate nuclear material accounting. These problems included poorly defined specifications and poor communications with the users, which resulted in long delays, considerable dissatisfaction with initial products, and several changes in responsibility for the development effort. Recently, a system that has been under development (LANMAS) was disseminated for review, evaluation, and trial applications. The FMAWG could have a role in ensuring that the direction of such efforts is more effective in the future and in guiding ongoing efforts to revise and enhance LANMAS. At the national level, the FMAWG could have an increased role in expanding the capabilities of NMMSS, the national nuclear material data base. Timely completion of upgrades (e.g., ability to include data on nuclear materials in waste and revisions of Composition of Ending Inventory codes, which are used to identify the forms of nuclear materials on inventory) will be key to maintaining the DOE's ability to respond to the increased number of requests for nuclear material data.

In addition, the FMAWG's role in reviewing measurement and disposition plans is diminishing. Although the FMAWG played a valuable role in the MAP and in reviewing the initial plan submittals, the FMAWG is now taking a less active role in reviewing revised plans or in monitoring progress.

Timeliness of Issue Resolution

A second concern is that the FMAWG has been slow to develop and communicate issues. Only one of the three FMAWG committees has been consistently active; the other two have discussed issues but have postponed significant actions until a revision to the DOE order was drafted. (As discussed previously, a revision to the MC&A order has been in a draft for a year and has not yet been formally issued for comment.) Progress has been slow, even on the discussion of operational issues. For example, it took almost a year from the time the MAP was completed (late 1996) until a set of recommendations was finalized and briefed to DOE's senior managers on the FMAWG activities (the NN co-chair briefed staff members in February 1997 and members of the senior management team in September 1997).

A key barrier to timeliness has been the fact that the FMAWG efforts are performed primarily by field personnel who generally have little time to work on FMAWG activities because of their job responsibilities. In many cases, the only opportunity for FMAWG field representatives to work on FMAWG activities is while they are attending meetings; little progress occurs between most meetings. Since meetings typically occur only about once a quarter and last only a day or two (often in conjunction with a related effort, such as an Institute of Nuclear Materials Management meeting, to save time and travel costs), it often takes months to perform even relatively simple tasks. Complex or contentious issues often require extensive discussion, and can easily extend over several meetings and thus take up to a year to resolve, even if a consensus can be reached.

The FMAWG has also had considerable difficulty in reaching consensus on the priorities for future actions. For example, some field personnel indicated that some issues important to the field, such as resource allocations to support site measurement plans, were not presented to senior management, and that some of the issues presented to senior management, such as measuring spent fuel, were not supported by a majority of the FMAWG.

The FMAWG consists of conscientious and dedicated people who are genuinely interested in making improvements. However, the concerns noted above indicate that the FMAWG is not accomplishing all that was envisioned in the 1995 Oversight report, nor is it achieving timely resolution of issues. In addition, the slow progress and perception that some issues are not being effectively communicated to senior management is contributing to waning enthusiasm for participation in FMAWG activities. When it was first formed, the field generally viewed the FMAWG as a positive step and was optimistic about the opportunity to make improvements. After the MAP effort was completed in 1996, NN participants indicated that the FMAWG had completed its major effort and could be dissolved; the field representatives voted overwhelmingly to continue

the FMAWG efforts. In recent meetings, however, a significant number of representatives indicated that they are becoming disenchanted with further participation because issues are not being acted on or because their concerns are not being addressed.

The slow progress and waning enthusiasm indicate that DOE must soon make a decision about the future of the FMAWG—either to discontinue it or to strengthen it. The results of this review indicate that there is much left to accomplish and that DOE continues to need a group such as the FMAWG to help resolve fissile material assurance issues and to coordinate efforts that require cooperation among sites. In fact, the difficult part of the FMAWG effort is just beginning as sites begin to encounter the technical and management challenges associated with improving and implementing their measurement plans. Because DOE Headquarters has limited technical expertise in MC&A (and some of the expertise that is available is focusing exclusively on international safeguards issues), DOE must rely on the field to provide expertise and to help resolve complex technical issues affecting DOE sites; the FMAWG continues to be a good source of such expertise.

If the FMAWG is to be more successful, however, DOE will need to resolve barriers that hinder FMAWG operations. One such barrier is the perception among some field personnel that the field does not have a sufficient voice in determining priorities. Increasing the role of field personnel in briefings to senior management could help in this regard. Increased participation by FM could also be useful in helping the FMAWG communicate its issues and recommendations to DOE program offices and senior management.

DOE also needs to address factors that hinder timely discussion and completion of FMAWG tasks. Many of the FMAWG efforts could be more useful if they were completed faster. The FMAWG needs to identify ways to increase communication and continue efforts between meetings. The program offices and operations offices can promote more timely progress by allowing their operations office and contractor MC&A personnel more opportunity to contribute to FMAWG efforts between the scheduled meetings. Increased use of subcommittees can also help with the timeliness of efforts. DOE should also consider giving the FMAWG an increased role in determining how NN research and development and technical support resources (such as NN-funded support at Sandia and other national laboratories) are used. For example, the FMAWG could have an increased role in assigning tasks to experts from national laboratories and thus could make use of the laboratory resources to perform tasks, such as evaluating technical issues or developing position papers, directly in support of FMAWG issues.

The FMAWG's ties to other ongoing DOE efforts also need to be strengthened in order to enhance communications, ensure that efforts are coordinated, and increase the visibility of and support for fissile material assurance. For example, the efforts of the FMAWG need to be coordinated with the ongoing Special Review Team review of safeguards and security. In addition, the FMAWG should consider providing a regular briefings to the Security Management Council. The Security Management Council could also consider using the FMAWG as a technical resource for addressing complex issues involving fissile material assurance.

Although a critical element, strengthening the FMAWG alone is not likely to achieve the desired results unless DOE also takes action to ensure that line management, from the program office to the operations office to the contractor senior management, is actively involved in fissile material assurance issues and accountable for fissile material assurance improvements. The experience with the MAP demonstrates that line management support is necessary to make progress on fissile material assurance issues. The FMAWG needs to increase its efforts to communicate issues to program office, operations office, and contractor line management. Correspondingly, DOE's senior managers need to establish a mechanism for ensuring that program offices, operations offices, and contractors place appropriate priority on fissile material assurance issues, that plans are implemented with clear milestones, and that line management is accountable for results.

Appendix B

Impacts of Fissile Material Assurance Weaknesses on the DOE Strategic Plan

The September 1997 U.S. Department of Energy (DOE) Strategic Plan identifies strategic goals for each of the DOE's primary functions (i.e., business lines). For each strategic goal, the Plan identifies specific objectives, strategies for meeting those objectives, and actions that are to be accomplished to meet the objectives. Figure B-1 presents extracts of some of the provisions (goals, objectives, strategies, and actions) of the Strategic Plan that are directly or indirectly relevant to fissile material assurance programs.

Several of the relevant provisions of the Strategic Plan, particularly those under the National Security Strategic Goal, specify needed improvements in safeguards and security. One of the actions specifically identifies upgrades in nuclear material protection, control, and accountability in 1999. To meet these provisions, DOE sites will have to address identified weaknesses in fissile material assurance, including weaknesses in nuclear material measurements, physical inventories, and accounting for holdup. As discussed elsewhere in this report, the rate of progress in addressing such deficiencies has not been impressive and may not be sufficient to demonstrate that the goals will be met. Particular attention needs to be devoted to needed upgrades that have long lead times, such as development of measurements standards and procurement of measurement equipment.

DOE has mechanisms in place to determine needed improvements (e.g., the Special Review Team) and to monitor progress (e.g., the Security Management Council). However, the primary focus of improvement efforts to date have been on improving protection of fissile material. As yet, there has not been sufficient attention to fissile material assurance issues. The Special Review Team should ensure that fissile material assurance issues are given sufficient attention and that the status is routinely reported to the Fissile Material Assurance Working Group (FMAWG) and the Security Management Council.

In addition to the provisions for improved safeguards and security, effective fissile material assurance programs are needed to meet several other provisions of the Strategic Plan. These include provisions related to:

- Reducing the proliferation threat, enhancing international safeguards, and reducing inventories of surplus fissile materials
- Ensuring the safety and health of the workforce and public, and protecting the environment
- Effectively managing facilities, materials, and cleanup efforts
- Potentially transitioning to Nuclear Regulatory Commission (NRC) regulation.

As discussed below, weaknesses in fissile material assurance could impact DOE's ability to meet the provisions of the DOE Strategic Plan.

Proliferation, International Safeguards, and Surplus Fissile Materials

Several provisions of the DOE Strategic Plan address international safeguards and treaties, non-proliferation programs, and efforts to reduce inventories of fissile materials. Weaknesses in fissile material assurance could directly or indirectly impact DOE's ability to meet a number of these objectives.

Much of DOE's fissile materials inventory is not ready to be offered up to international inspection because it does not have defensible inventory values. Further, DOE is experiencing some difficulties in the transition to International Atomic Energy Agency (IAEA) requirements as fissile materials have been offered for inspection by the IAEA in recent years. Further, there are differences between DOE and non-DOE requirements that make a transition from one to the other difficult and costly. In addition to differences in policies, implementation of requirements has not always been as stringent at

EXCERPTS FROM DOE STRATEGIC PLAN (SEPTEMBER 1997) PROVISIONS RELEVANT TO FISSILE MATERIAL ASSURANCE

NATIONAL SECURITY STRATEGIC GOAL: Support national security, promote international safety, and reduce the global danger from weapons of mass destruction.

- Demonstrate, in FY 1998, more effective safeguards and security throughout the DOE national security enterprise.
- Ensure and enhance protection of nuclear materials, sensitive information, and facilities.
- Initiate, in FY 1999, needed nuclear material protection, control, and accountability upgrades at DOE facilities with weapons-usable material.
- Further the protection of all U.S. origin nuclear materials in the U.S. and abroad from possible theft, loss, or illicit trafficking.
- In FY 1999, include information on nuclear materials contained in waste in a new Departmental data base for all nuclear materials.
- Reduce nuclear weapons stockpiles and the proliferation threat caused by the possible diversion of nuclear materials.
- Reduce inventories of surplus weapons-usable fissile materials worldwide in a safe, secure, transparent, and irreversible manner.
- Place more than 20 metric tons of excess highly enriched uranium under IAEA safeguards in FY 1999.
- In FY 1998, begin the transfer of 50 metric tons of U.S. surplus highly enriched uranium to the United States Enrichment Corporation for dilution and subsequent sale.
- Strengthen the nuclear nonproliferation regime through support of treaties and international agreements.
- Establish guidelines/requirements for global monitoring and onsite inspections to implement the Comprehensive Test Ban Treaty upon ratification by the Senate.
- Support, in FY 1999, negotiations on the Fissile Materials Cut-Off Treaty.

ENVIRONMENTAL QUALITY STRATEGIC GOAL: Aggressively clean up the environmental legacy of nuclear weapons and civilian nuclear research and development programs, minimize further waste generation, and permanently dispose of the nation's radioactive waste.

- Reduce the most serious risks from the legacy of the U.S. nuclear weapons complex first.
- Stabilize and safely store about 100 metric tons of heavy metal spent nuclear fuel during FY 1998 and FY 1999.
- Stabilize and safely store more than 1,000 kilograms of plutonium at Hanford Site during FY 1998 and FY 1999.
- Clean up as many as possible of the Department's 83 remaining contaminated geographic sites by 2006.

CORPORATE MANAGEMENT STRATEGIC GOAL: The Department of Energy continuously demonstrates organizational excellence in its environment, safety, and health practices, communication and trust efforts, and its corporate management systems and approaches.

- Ensure the safety and health of the DOE workforce and members of the public, and the protection of the environment in all DOE activities.
- Strengthen the management of projects, materials, facilities, land, infrastructure, and other assets to ensure safe, sound, and cost-effective operations and appropriate maintenance of sites, and to ensure project results.
- Initiate three pilot projects for independent external regulation (by the NRC) during FY 1998.

Figure B-1.

DOE sites as at non-DOE sites. From their inception, sites subject to IAEA verification have had to demonstrate to external inspectors that all materials are accounted for. In contrast, most of the fissile materials in DOE's possession were at one time part of the defense program, and were historically not subject to external verification. Consequently, the attention to and priority of fissile material assurance at DOE sites have varied over the years, resulting in many situations where DOE sites' measurements or accounting practices cannot withstand the scrutiny of an external inspection.

The 1995 DOE Office of Oversight report on increasing fissile inventory assurance discussed difficulties that DOE facilities would face if required to comply with international and bilateral agreements. The Office of Oversight indicated a need to increase the level of assurance in DOE's fissile material measurement program and to develop a consolidated approach to IAEA and bilateral inspections that is consistent across DOE facilities. However, DOE's approach to the problems associated with placing materials under IAEA safeguards is best characterized as fragmented and uncoordinated. As yet, the FMAWG has not focused on the international issues, DOE has not effectively coordinated its efforts to bring inventory values and policies in line with international requirements, and DOE orders and guidance have not been revised to reflect new considerations associated with IAEA safeguards and bilateral agreements.

In recent years, three DOE sites have offered significant amounts of fissile materials for inspection by the IAEA. The materials generally had reasonably defensible measurements and accountability values. However, these same sites had more materials that were not needed for defense purposes but that had measurements and accountability values insufficient to satisfy IAEA requirements. Even though sites were selective about what was placed under IAEA safeguards, a number of issues relating to fissile material assurance have arisen during the short time since the transition. For example, there have been several incidents where the IAEA has had difficulty making assurance statements about the inventories at DOE sites because of violations of procedures for moving materials, remeasurement of items under IAEA safeguards, and inability of the facility accounting system to properly account for the materials under IAEA safeguards.

The problems that have occurred to date with DOE materials under IAEA safeguards were not insurmountable and could be readily solved. However, these problems serve to highlight the difficulties that DOE will face in the near future, because much of DOE's fissile material is not currently suitable for placing under IAEA or bilateral safeguards.

To avoid increasingly frequent problems as DOE places more materials under IAEA, DOE needs to evaluate its materials and fissile material assurance practices from the standpoint of the eventual disposition of the material. Although the precise amounts are not known at this time, much of DOE's fissile materials will not be needed for defense purposes and will thus be offered for international inspection by the IAEA, barring a significant change in the geopolitical landscape. In this context, weaknesses in the U.S. domestic fissile material assurance program could reduce U.S. credibility in the international community, thereby limiting DOE's ability to meet its Strategic Plan provisions on enhanced international safeguards, nonproliferation, treaties, and bilateral agreements.

A specific example involves the adequacy of measurement equipment at some DOE sites. As part of the DOE nonproliferation effort, DOE is sending equipment to Russia that is more technologically advanced than that used at U.S. sites. Thus, DOE may be in the embarrassing position of not being able to adequately measure its own materials, although it has provided similar measurement capabilities to other countries. A contributing factor to this situation is that measurement equipment being sent to Russia, often developed by DOE national laboratories, is paid for under a well-funded non-proliferation program. In contrast, measurements equipment at DOE facilities often must be purchased from overhead accounts and must compete with other site and facility upgrades for funding.

Another specific concern is DOE's ability to meet the provision that specifies placing a large quantity, 26 metric tons, of highly enriched uranium under IAEA safeguards in FY 1999. Much of DOE's highly enriched uranium is not suitable for placing under IAEA safeguards, and other highly enriched uranium does not have defensible inventory values. Conceivably, significant amounts of highly enriched uranium may have to be measured or will have to be transferred, repackaged, or processed before it can be

measured. For some highly enriched uranium, it may be necessary to develop standards before measurements can be made. Such activities can take considerable time and effort.

Similar concerns can be envisioned when transferring materials to the United States Enrichment Corporation (USEC), which will be accepting materials under NRC regulations. A number of problems can occur if material transferred to USEC does not have adequate measurements. The materials may not meet NRC standards and may thus not be accepted, or there could be concerns associated with precisely accounting for the highly enriched uranium transferred to USEC. In addition, if materials are to be "blended down," DOE will need good accounting and measurements to demonstrate to the international community precisely how much highly enriched uranium has undergone this process.

Between the IAEA and USEC, the Strategic Plan specifies a total of up to 70 metric tons of highly enriched uranium that will be transferred or offered for IAEA inspection. Such material will need to have defensible measurements and inventory values, and effective planning will be needed to meet these ambitious provisions. It may be prudent to perform a realistic assessment of the highly enriched uranium inventories to ensure that DOE can be confident that issues related to measurements and accountability will not delay it in meeting the Strategic Plan provisions. Such an assessment needs to identify specific quantities of highly enriched uranium that are being considered for placing under IAEA safeguards or transferring to USEC. It would also need to address the adequacy of measurements and inventory values as well as any transfers, processing steps, dilution, or additional needed measurements to make the material suitable for USEC or IAEA.

Environment, Safety, and Health (ES&H)

Ensuring effective ES&H programs is one of DOE's highest priorities. Some ES&H programs, such as radiation protection and criticality safety, have important interfaces with fissile material assurance programs. For example, criticality safety often involves specifying spacing limits (e.g., items must be at least 12 inches apart) or mass limits (e.g., a safe mass limit, such as no more than 100 grams in a glove box, or a processing constraint, such as no more than a specified number of grams of plutonium per liter of solution). Such limits require accurate knowledge of the amount of material in each item, and particularly that the amount of material is not underestimated. In many instances, the accountability values for items are used as the basis for determining the amount of material in each item.

In addition to their safeguards benefits, recent DOE-wide efforts, such as the measurement assessment project (MAP), and site-specific programs, such as measuring holdup, have provided DOE with a better characterization of the uncertainties in the quantities of materials and the location of significant pockets of holdup. Properly used, this improved characterization can benefit ES&H programs. For example, a good understanding of the location of holdup can help work planners to anticipate hazards and establish effective controls during decontamination and decommissioning (D&D).

Although DOE's characterization of materials has improved in the past three years, the information available within the safeguards organizations is not always being used effectively, and there are still situations where a lack of accurate information about nuclear materials can impact safety. For example:

- An accurate characterization of the types, locations, and quantities of nuclear materials is important in controlling exposures to workers.

- From a criticality safety perspective, it is important to ensure that the amounts of material in each item are accurate (or conservatively estimated) so that safe mass limits and safe geometry are maintained wherever nuclear materials are used and stored.

- Good characterization and monitoring of holdup are needed to prevent unnecessary and unexpected radiation exposure and/or accumulation of a critical mass.

Historically, weaknesses in the interfaces between fissile material assurance and ES&H have contributed to criticality events at DOE processing plants (e.g., containers had incorrect values and markings, contributing to significant events at the Y-12 Plant and Wood River Junction (which was a uranium scrap recovery facility that is no longer operating). In addition, in many instances criticality constraints have been violated because of incorrect accountability values and/or measurements. The potential for violating a criticality safety limit is very real if materials do not have defensible accountability values. There are significant concerns with the accountability values for scrap and waste, particularly in materials that have been in storage for long periods, in some cases more than 20 years. There have also been instances of large discrepancies (several kilograms) between the accountability value and the actual amount determined when the materials were actually measured. In some cases, the measured amounts were 10 times greater than expected, and in a few cases, items were found to contain plutonium when they were thought to contain highly enriched uranium.

Such discrepancies could contribute to a criticality safety limit violation and, in the worst case, a criticality event causing fatalities or injuries and a significant cleanup problem. For example:

- Safe mass limits or safe geometry limits could be violated if one or more items had significantly more fissile material than expected. There have been instances where an item expected to have less than 100 grams actually contained more than a kilogram. While discrepancies of this magnitude are relatively rare, they are very significant because such discrepancies exceed the minimum critical mass of uranium or plutonium.

- Nuclear material measurements must be accurate to ensure that batch processing constraints are not violated. Measured values are of special significance for materials that are to be blended, and DOE is currently blending materials to lower the enrichment to reduce the proliferation threat.

- Many DOE facilities are consolidating nuclear materials, which often includes activities such as combining materials from several containers into a single container and/or placing more materials in a smaller area. While such consolidation is appropriate, the nuclear material content of containers must be accurate to avoid criticality hazards.

- If the holdup in equipment is not known and considered in the criticality safety evaluations, criticality constraints could be violated. (Criticality evaluations often do not include estimates of holdup.)

- Department of Transportation packaging rules and shipping regulations are based on nuclear material quantities. If the inventory values are incorrect, DOE could be in violation of those regulations.

Even a violation of a criticality safety limit that does not result in a criticality violation could be devastating to DOE's efforts to maintain the vitality of its mission. Many operations at the Y-12 Plant have been shut down for several years to address weaknesses in the criticality safety program, and LLNL plutonium operations were recently halted because of violations of criticality safety mass limits. Particular attention is needed to ensure that weaknesses in fissile material assurance do not result in violations that cause criticality accidents or criticality safety infractions, which could result in additional shutdowns of operations needed for defense.

The Office of Oversight's safeguards and security site profiles and other reviews indicate that several DOE sites could benefit from a stronger interface between the safeguards data (e.g., nuclear material inventories, measured values, and uncertainties) and ES&H programs, most notably criticality safety and radiation protection. At many DOE sites, the information available within the safeguards organization is not being used as effectively as it could be for a variety of reasons:

- Safeguards data may be classified or sensitive and has historically been closely held.

- Safeguards personnel rarely interface with ES&H organizations and personnel involved with operational safety (e.g., because of organizational separation).

- ES&H personnel may not have confidence in information developed for safeguards purposes (e.g., safeguards measurements strive for accuracy, while criticality safety measurements need to be conservative).

- Safeguards information (e.g., measurements data) is not routinely shared with ES&H or recognized as a resource by ES&H.

The obstacles to better interfaces are not insurmountable. For example, fissile material assurance values and measurements can be effectively used for criticality safety mass limits as long as ES&H and safeguards personnel interact to minimize the potential for error and/or bias in nuclear accountability measurements. At some sites, there is an effective interface between ES&H and safeguards in some areas. For example, nuclear measurements performed for accountability purposes are used to ensure that criticality safety constraints are met. DOE sites can conserve resources by properly using safeguards values to determine whether criticality safety constraints are met, rather than performing a separate measurement for criticality evaluations. In cases where it is prudent to perform measurements specifically for criticality safety purposes, accountability values can provide a valuable independent check.

Facilities, Materials, and Cleanup

A good characterization of nuclear materials is also needed to effectively manage DOE facilities and cleanup efforts. Several provisions of the Strategic Plan specify improved planning, increased programmatic integration, improved decision-making processes based on accurate information, and better links between resource allocations and plans.

An accurate understanding of the amounts and types of materials in DOE facilities is a prerequisite to effective and efficient facility management and cleanup. Specifically, a good characterization of nuclear materials is needed for effective planning and resource allocation, such as:

- Planning for safe equipment removal and D&D

- Determining what resources are needed to ensure that materials are processed to a stable form and packaged for long-term storage and eventual disposition

- Determining what resources are needed to perform fissile material assurance functions, such as inventories and measurements

- Providing accurate information for requests for proposals and contractual performance objectives.

The FMAWG has reported to DOE's National Security Business Line that DOE does not have sufficiently accurate information on hand about the nuclear material inventory to allow facilities to properly plan for D&D. In addition, some policy issues, such as termination of safeguards, could affect planning for facility disposition and resource allocation. For example, policies covering termination of safeguards could affect the costs of facility operations as the D&D effort progresses.

Transition to NRC Regulation

DOE and the NRC are evaluating the advantages and disadvantages of transitioning some or all of DOE facilities to NRC regulation and enforcement. It is not yet clear whether such a transition would include safeguards and security. If it did, the time and costs of bringing DOE fissile materials into compliance with NRC requirements would be significant, and would require considerable planning and coordination.

Although safeguards issues need to be factored into decisions about external regulation, the ongoing pilot program, in which NRC is performing trial regulation of three sites, will not be a good indicator of DOE sites' ability to transition to NRC's safeguards and security regulations. The initial three sites do not have significant quantities of special nuclear materials or the type of problems with fissile material assurance that most large DOE sites face. Fissile material assurance could be a major impediment to regulatory transition.

Overall Summary

Through efforts such as the MAP, DOE has come a long way toward characterizing its fissile

materials. It is now important to take the next step and systematically analyze those materials to determine whether weaknesses in fissile material assurance will significantly impact DOE's ability to meet strategic goals, including goals related to safeguards and security, nonproliferation, ES&H, and facility management. Such impacts need to be understood and incorporated into site plans. A systematic assessment needs to incorporate the views of program offices, operations offices, contractors, the DOE Office of Nonproliferation and National Security, and others. The FMAWG is well positioned to provide support to such efforts.

As analysis of fissile material assurance issues against the Strategic Plan may also provide a useful and defensible basis for determining safeguards priorities.

Analyses need to be tailored to each site and program. However, DOE also needs to establish a significant Headquarters role in analyzing impacts and priorities, since many of the key decisions cannot be made by individual sites. As one important example, materials to be included in the 26 tons that will be offered up for IAEA inspection need to be determined in coordination with Headquarters.

Technical Terms Used in This Report

Components of Fissile Material Assurance

Accountability: Systems and administrative controls to perform fissile material measurements, maintain records and provide reports, perform physical inventories, perform data analysis to detect losses, and to investigate and resolve apparent losses. For example, administrative controls restrict materials to certain locations (called Material Balance Areas) and require a formal process for recording movements into or out of these locations.

Accounting Systems: Accounting systems register material quantities, track items and quantities through transfers and processes, record measurement data and uncertainties, and provide data for reporting and analysis.

Measurements: Measurements are performed for various purposes. **Accountability measurements** are performed to quantify the amount of fissile material in an item or location. These measurements are the official values that are recorded and tracked in the accounting system. **Verification measurements** are performed as part of physical inventories to verify (by quantifying the amount of fissile material in an item) that the expected amount of fissile material is still present (thereby detecting removal of material from an item and/or substitution of non-fissile materials for fissile materials—in short, uncovering a theft of fissile materials). **Confirmation measurements** are also performed as part of physical inventories to verify that an item has at least some of the expected attributes (a quicker, but less accurate way to detect some types of theft or diversion but not others). Measurements include both destructive measurements, in which a portion of the material being measured is removed from the item in question, and non-destructive assay, in which the item is measured without changing its form or destroying it. Various types of equipment (e.g., calorimeters and neutron counters) are used to measure the wide variety of materials at DOE sites.

Physical Inventories: The process of quantifying the amount of fissile material on hand by physically ascertaining its presence using techniques such as visual verification, sampling, and measurements. Fissile materials may be contained in discrete items or storage units (e.g., tanks), present in processes such as blending or stabilization processes, or present as holdup remaining in equipment or facilities after materials have been removed. In conducting a physical inventory a portion of items on the inventory records are located, visually checked, and measured. Sample sizes are chosen so that an acceptable level of confidence can be established regarding the amount of fissile material contained in the item inventory.

Inventory Reconciliation and Evaluation: The process of comparing physical inventory results to the fissile material accounting records then reconciling and evaluating any differences. After making corrections for any data or recording errors, the differences between the physical inventory results and the accounting record totals are calculated and reported in the accounting records as an inventory difference. Inventory differences must be evaluated to determine if a theft or diversion of fissile material has taken place. In accounts where measurements and/or processing occur, inventory differences can be expected because of the uncertainties associated with measurements and process variability. The magnitude of these differences is estimated and statistical limits are calculated for evaluating the inventory difference.

Reporting: Fissile material quantities are continuously tracked on site data bases and periodically reported to a national data base. Any significant item discrepancies or inventory differences are reported and immediately investigated. Such reporting enables DOE to quantify the amount of fissile materials on hand across the Department.

Other Commonly Used Terms

Defensible Measurement: In order for a measurement result to be considered defensible, documentation must show that the measurement was made on a calibrated measurement system operating within the limits established by a measurement control program. The standards used to calibrate and maintain the system must be traceable to national standards and the measurement should be repeatable.

Fissile Material: Fissile materials are capable of undergoing nuclear fission (splitting the nucleus of an atom). The fissile materials of concern to DOE are enriched uranium and plutonium.

Fissile Material Assurance: A condition or state where knowledge, confidence, and reliability in fissile material inventory information is maintained.

Holdup: Fissile material remaining in process equipment (i.e., glove box lines, piping, tanks, and ventilation ducts) and facilities after the stored and in-process materials have been removed. In many cases, holdup cannot be removed until the equipment or facility has been dismantled.

Inventory: A record of all items and locations at the site that contain fissile material and the amount of material contained in each.

Inventory Value: The recorded amount of nuclear material in an item or location.

Item: Any discrete object that includes fissile material in its makeup, or a container (e.g., can, drum, jar, cylinder, tank, process equipment) that holds fissile material. Items have a unique identification and a known fissile material mass.